AN ASSESSMENT OF STORMWATER MANAGEMENT RETROFIT AND STREAM RESTORATION OPPORTUNITIES IN BALLENGER CREEK WATERSHED, FREDERICK COUNTY, MARYLAND

Prepared for

Frederick County
Division of Public Works
118 North Market Street
Frederick, Maryland 21701-5422

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9200 Rumsey Road
Columbia, Maryland 21045

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1.0 INTRODUCTION

Urban stresses on watershed health and impacts to the quality of a watershed's streams are well documented (Table 1-1). As such, Frederick County continues to sponsor a series of studies in its high priority watersheds to identify watershed restoration projects that could improve and protect water quality and stream conditions. This report documents the findings of the Ballenger Creek watershed restoration study conducted by Versar, Inc., under contract to the Frederick County Division of Public Works (Task Order No. 02-CSC-04-79374).

Table 1-1. Major pollutants (stressors) in urban or suburban areas and their effect on streams (Fairfax County 2001)

Stressor	Source	Environmental Effect
Altered Hydrology	Conversion of forested/natural areas to impervious surfaces. Increases amount and rate of surface runoff and erosion.	Overall channel instability, habitat degradation or loss.
Nutrients (Nitrogen and Phosphorous)	Improper use (over application) of lawn fertilizers.	Stimulate algae blooms. May reduce sunlight reaching stream bottom, limiting plant growth. Rapid accumulation of dead algae decomposes aerobically, robbing other stream animals of oxygen.
Sediment	Poorly managed construction areas, winter road sand, instream erosion, bare soils.	Clogs gills of fish and insects, embeds substrate, reducing available habitat and potential fish spawning areas.
Channel Alteration	In very urban areas, concrete, metal and rip-rap stabilization of stream banks. Stream channelization, flood erosion control.	Major habitat reduction/elimination, changes flow regime dramatically. Dramatic alteration of biological communities can cause Thermal Loading and Sediment problems. Transfer erosion potential downstream.
Riparian Loss	Development. Clearing or mowing of vegetation all the way up to stream banks.	Increase water temperature, greater pollutant input, less groundwater recharge, greater erosion potential from streambanks. Alters community composition.
Toxics	Various. Underground storage tank leakage, surface spills, illegal discharges, chlorine from swimming pool drainage, etc.	Can have an immediate (acute) affect on stream biota if levels are high enough. May be chronic, eliminating the more sensitive species and disrupting ecosystem balance over time.
Organic Loading	Sewage leaks, domestic and livestock wastes, yard wastes dumped into streams.	Human health hazard (pathogens), similar oxygen depletion situation as Nutrients. Causes benthic community shift to favor filter feeders as well as organisms with low oxygen requirements.
Thermal Loading	Water impoundments (lakes or ponds). Industrial discharges and power plants. Removal of riparian tree cover. Runoff from hot paved surfaces.	Biological community structure altered, shift to species tolerant of higher temperatures, sensitive species lost. Dissolved oxygen depletion.
Exotic Species	Human transportation and release (intentional and unintentional).	Invade ecosystem and out compete native species for available resources (food and habitat). Some introduced intentionally to control other pests.

1.1 BALLENGER CREEK WATERSHED STUDY AREA

The Ballenger Creek Watershed in Frederick County, Maryland, is located immediately south of the City of Frederick (Figure 1-1). The headwaters are in the Catoctin Mountains and the watershed drains eastward past the City and the I-270 corridor to the Monocacy River. The western third of the watershed is relatively rural, while the eastern two-thirds contain the County's most heavily developed areas, which have rapidly expanded since the mid-1970s.

Compounding the effects of urbanization, limestone geology underlying the eastern portions of the watershed is easily dissolved by both groundwater and stormwater infiltration. When the underlying limestone bedrock is dissolved, changes in groundwater elevation brought on by drought, groundwater withdraw, and other hydrologic modifications can result in surface collapse, forming karst features such as sinkholes and depressions (Figure 1-2). Additionally, karst geology can result in disappearing streams, intermittent streamflow, and rapid infiltration of surface water (which may contain pollutants) into underlying aquifers.

1.2 GOALS AND OBJECTIVES

Building upon previous efforts to assess watershed conditions and stressors affecting Ballenger Creek (Roth et al. 2001, Hunicke and Yetman 2005), the goal of the study was to identify and evaluate specific opportunities for additional stormwater management (SWM) controls and stream restoration that could cost-effectively improve conditions in the Ballenger Creek watershed. Utilizing the methods outlined below, Versar worked in collaboration with County personnel to: 1) use existing information to target efforts and solutions to the most promising areas, 2) conduct field site investigations to refine proposed concepts for solutions, 3) host a public meeting to solicit input from local stakeholders, 4) develop a prioritization of opportunities, and 5) prepare a report containing recommendations and conceptual plans for the best watershed restoration opportunities.

At the outset of this project, the County identified a number of objectives and guidelines, as outlined below:

- To focus primarily on urban stormwater management improvements; however, other opportunities identified in this effort, including agricultural best management practices (BMPs) can be pursued via the County's extensive network of Community Restoration partners.

- The best opportunities for addressing urban stormwater issues will be:
  - located on County-controlled land or that originate on private property and impact County-controlled infrastructure

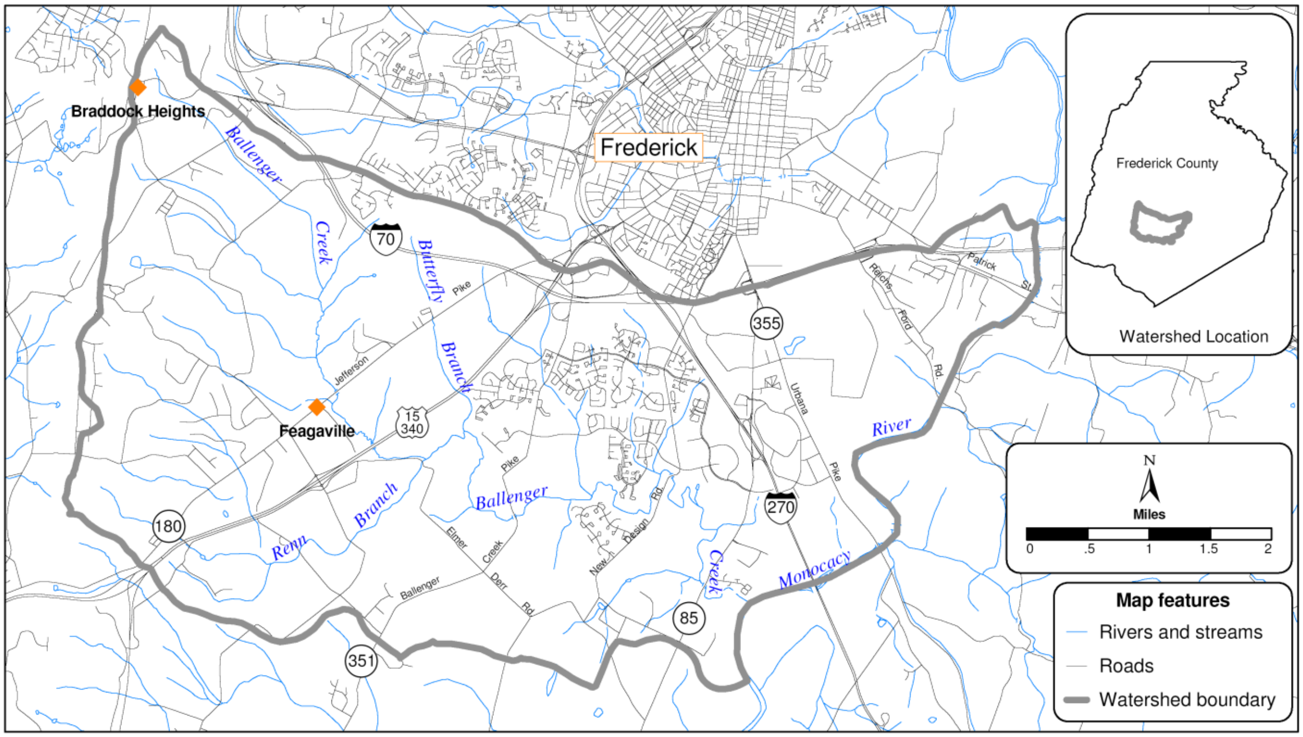


Figure 1-1. Ballenger Creek Watershed, Frederick County, MD

Figure 1-2. Sinkhole repair in the bottom of a stormwater management facility, Gilford Road across from Wal-Mart, July 2000.

- have synergies with Frederick County's existing Capital Improvement Program (CIP) projects (e.g., Ballenger Creek Trail Project)
- address or accommodate the genesis of the problem (i.e., increased volume and velocity of stormflow), and
- have good visibility to encourage public acceptance of new and potentially innovative restoration measures.

- To incorporate public input into the problem identification and site selection process.
- Selected projects will likely be implemented through the County's CIP, which has minimum project requirements, namely projects must cost greater than $100,000 and have more than a 10-year life-span.

Based on these guidelines, two types of projects have been identified: those that could be implemented through the County's CIP and those more suitable for implementation by the County's Community Restoration partners. To facilitate decision-making, a prioritized list of projects was developed to help focus implementation efforts, with detailed conceptual plans prepared for the best CIP opportunities; the remainder of opportunities, both CIP and Community Restoration, have been recorded for use as opportunities arise. While many of the individual projects identified in this study do not meet the minimum cost threshold, grouping projects based on location (e.g., by subwatershed) and type will likely increase the benefit and efficiency of implementation, as well as exceed this minimum cost threshold.

An additional objective is to address the County's current National Pollutant Discharge and Elimination System (NPDES) Municipal Separate Storm Sewer System Discharge Permit goal to provide treatment for 10 percent of impervious areas that are currently not served by stormwater management. Based on impervious estimates from the County's 2002 NPDES Annual Report, there are 804 untreated urban impervious acres within the County's portion of Ballenger Creek's watershed. To this end, providing stormwater management controls for 80 untreated impervious acres would help satisfy the watershed's proportion of the County's overall 10 percent untreated goal.

It is also important to note that if left unchecked, many of the stormwater runoff and associated nonpoint source pollution problems noted in this study may lead to long-term impacts to the quality of Frederick County's water resources, as well as exacerbate regional water quality problems by contributing to cumulative impacts downstream in the Monocacy and Potomac Rivers, and ultimately in the Chesapeake Bay. Potential impacts to water resources include:

- Destabilization of drainage pathways and stream channels
- Damage to infrastructure and private property from erosion
- Reduction of drinking water quality and increased treatment costs for local water supplies, and if left untreated, potential public health and safety concerns

- Reduction of the quality and diversity of physical habitat available to aquatic organisms
- Reduction in species diversity and abundance within stream biological assemblages
- Reduction in economic, social, and aesthetic benefits to local communities (e.g., tourism, recreational fisheries, sense of well-being, community identity, etc.)

2.0 METHODS

In order to identify the best opportunities for stormwater controls and stream restoration within the study area, the project team used a restoration targeting approach used in a similar watershed restoration study in the County's Lower Bush Creek watershed (Perot et al. 2003), as well as in other watershed investigations (Southerland et al. 1999; Southerland et al. 2000; Roth et al. 2002). This approach uses both existing data and new investigations, to carry out the following steps:

1. Determine general problem types and trends in stream condition
2. Develop criteria within existing information to distinguish problem types
3. Identify areas or sites experiencing degradation and the most likely causes of those problems
4. Develop and apply criteria to rank candidate restoration sites
5. Recommend site-specific restoration measures

2.1 REVIEW OF EXISTING STUDIES

As the first step toward characterizing general problem types and planning our subsequent investigations, we reviewed existing background information on the most significant problems affecting streams in the study area.

As previously mentioned, a baseline study of watershed conditions was conducted in 2001 (Roth et al.), which characterized general watershed conditions, including land use, degree of imperviousness, location of stormwater management facilities, a visual assessment of watershed conditions, biological stream monitoring, and other information. Information from this study was used to better understand historical and planned growth patterns, stormwater management practices in different areas, stream conditions, and other watershed characteristics.

Subsequently, Frederick County coordinated with the Maryland Department of Natural Resources (MDNR) to conduct Stream Corridor Assessment (SCA) surveys to rapidly assess the general physical conditions of the stream corridor in Ballenger Creek (approximately 36.5 miles). SCAs are conducted by a trained team of AmeriCorps volunteers, who walk the streams and collect field data for observed environmental problems (Yetman 2001). The stream walks were completed by MDNR in March 2004; and a final report was issued by the State in June 2005 (Hunicke and Yetman 2005). After the field work was completed, SCA data were entered and organized into a database and a geographic information system (GIS). A summary of the results of environmental problems observed in the Ballenger Creek SCA is presented in Table 2-1.

Table 2-1. Summary of observed environmental problems in the Ballenger Creek SCA.

Identified Problem	Number of Sites	Estimated Length	Very Severe	Severe	Moderate	Low Severity	Minor
Channel Alteration	8	N/A	0	1	4	1	2
Erosion Site	34	73,387 feet (13.9 miles)	1	6	14	11	2
Exposed Pipe	4	N/A	0	0	2	2	0
Fish Barrier	38	N/A	0	5	13	10	10
Inadequate Buffer	42	Left bank 96,796 feet (18.3 miles) Right bank: 87,036 feet (16.5 miles) Total length: 183,832 feet (34.8 miles)	10	9	9	5	9
Pipe Outfall	50	N/A	0	1	6	19	24
Trash Dumping	6	N/A	0	1	2	1	2
Unusual Condition	10	N/A	1	2	2	4	1
Total	192		12	25	52	53	50
Representative Sites	27						
Comments	3						

The Maryland Geologic Survey (MGS) recently completed a field survey of karst features in Frederick County (Brezinski 2004). As part of this survey, MGS developed a GIS database of limestone formations and known karst features such as sinkholes and depressions (Figure 2-1). Based on their review, MGS also developed a karst susceptibility index that rates the relative susceptibility of the various limestone formations in the Frederick Valley to karstic features. Limestone formations most susceptible to karstic features include the upper Lime Kiln Member of the Frederick Formation and the Woodsboro, Fountain Rock and Ceresville Members of the Grove Formation (Brezinski 2004).

2.2 GIS MAPPING AND MAP REVIEW

Versar compiled an extensive collection of spatial data from the County and other public sources for the Ballenger Creek Watershed. Mapping spatial data in a GIS was critical to this effort, combining a wide range of discrete data to help the project team integrate existing data and identify potential opportunities for improving stormwater controls and stream conditions in the watershed (Table 2-2). To help identify these opportunities for watershed improvements, a series of six large format maps were produced so that the project team could review site details and mark locations on the maps (Figure 2-2). To aid in reviewing site conditions, the County's orthophotography (from March 2000) was overlain with stormwater piping network information (completed in 2004) and printed as a 70-page indexed map book at a scale sufficient to view conditions on the ground (Figure 2-3).

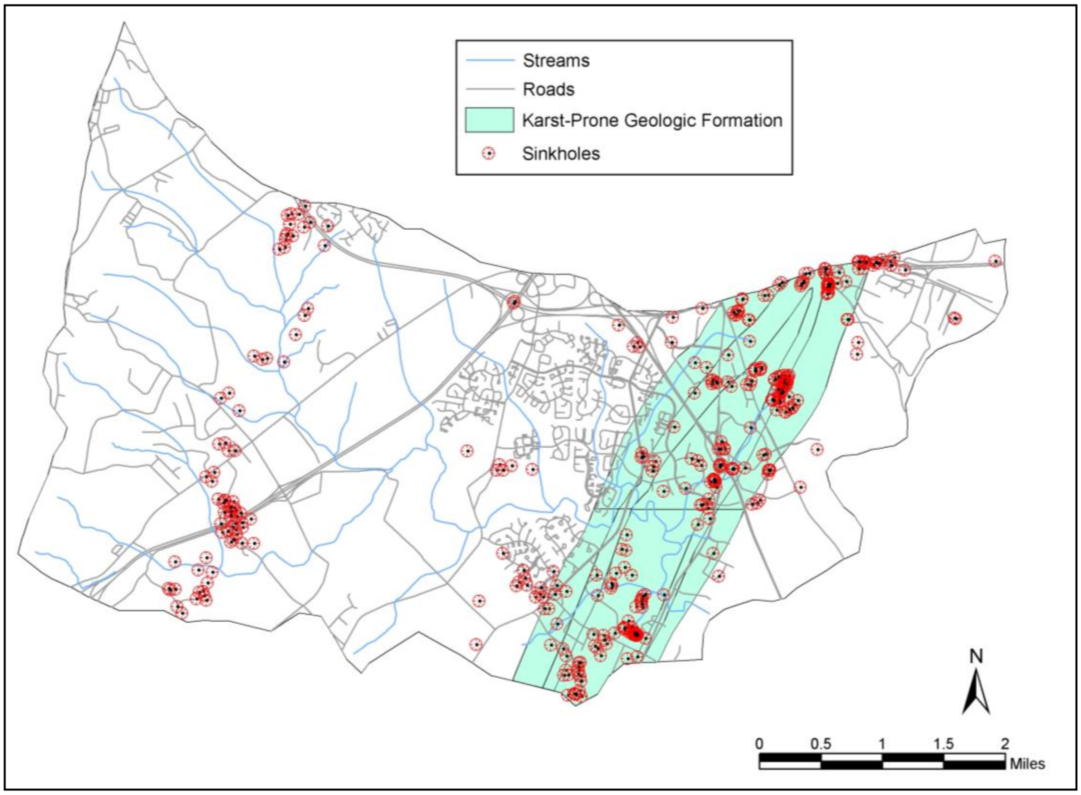


Figure 2-1. Karst prone areas and known sinkholes within Ballenger Creek Watershed (compiled from Brezinski 2004 and Frederick County 2005).

Table 2-2. GIS data layers utilized to help identify potential stormwater retrofits and stream restoration opportunities

Feature	Source	Feature	Source
Property boundaries	MD Property View tax maps	County owned property: schools, parks, unimproved land	Frederick County
Roads & bridges	Frederick County	City and Town boundaries	Frederick County
Hydrography	Frederick County	Streambank erosion	MDNR SCA
Stormwater management facilities	Frederick County	Inadequate riparian buffer	MDNR SCA
Stormwater ponds	Frederick County	Stream habitat rating	MDNR SCA
Stormwater drainage networks	Frederick County	Fish barriers	MDNR SCA
Stormdrain inlets and outfalls	Frederick County	Pipe outfalls	MDNR SCA
Orthophotography	Frederick County	Habitat condition	MDNR SCA
Sinkholes	Frederick County	Exposed pipe	MDNR SCA
Sinkholes and karst-prone geologic formations	Maryland Geological Survey	Channel alteration	MDNR SCA
Non-County owned parks	Frederick County	Properties denied access during SCA	MDNR SCA

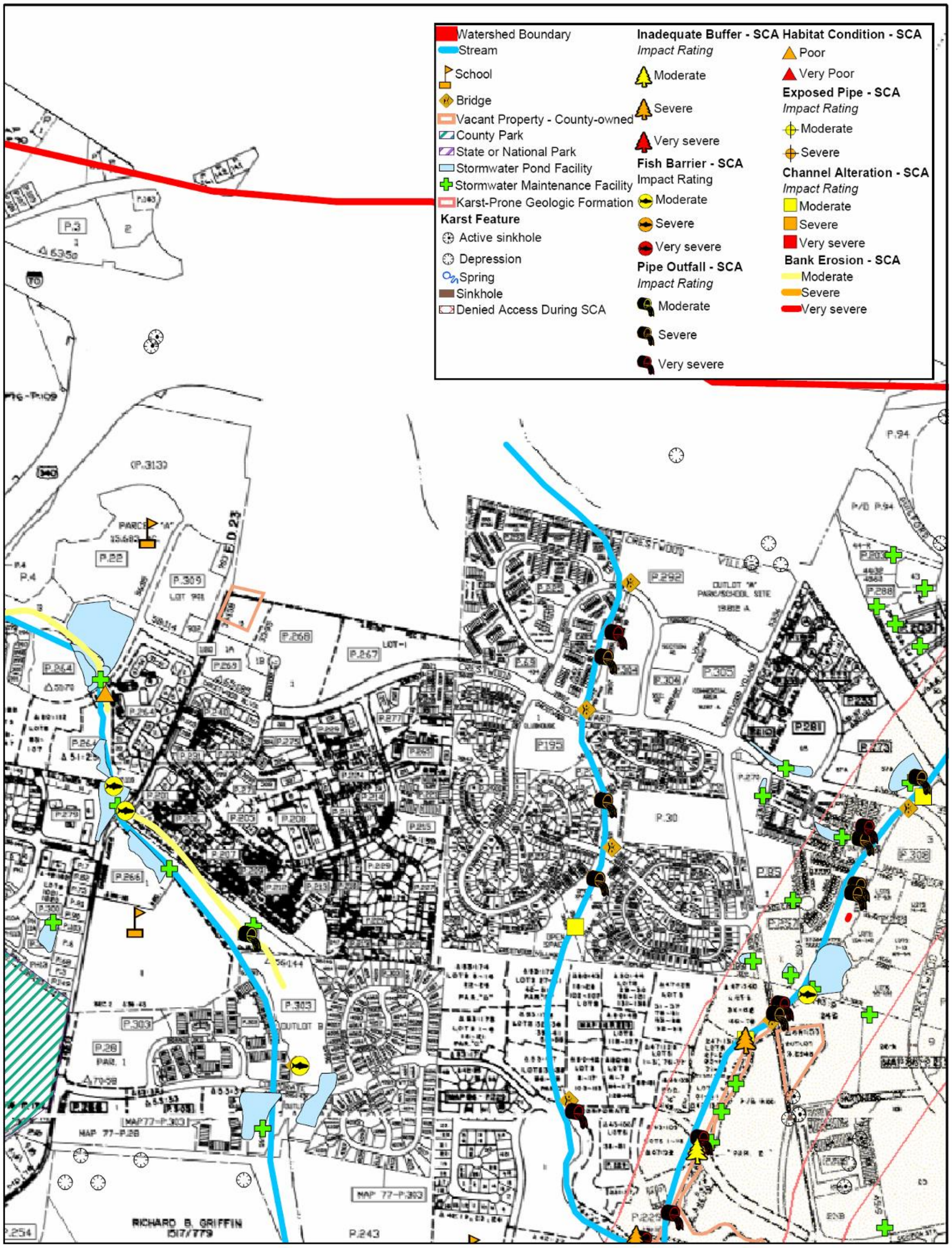


Figure 2-2. Example of various GIS data utilized to help identify potential stormwater retrofit and stream restoration opportunities in Ballenger Creek watershed. This map shows the north-central portion of the watershed and is one in a series of six maps used in analysis.

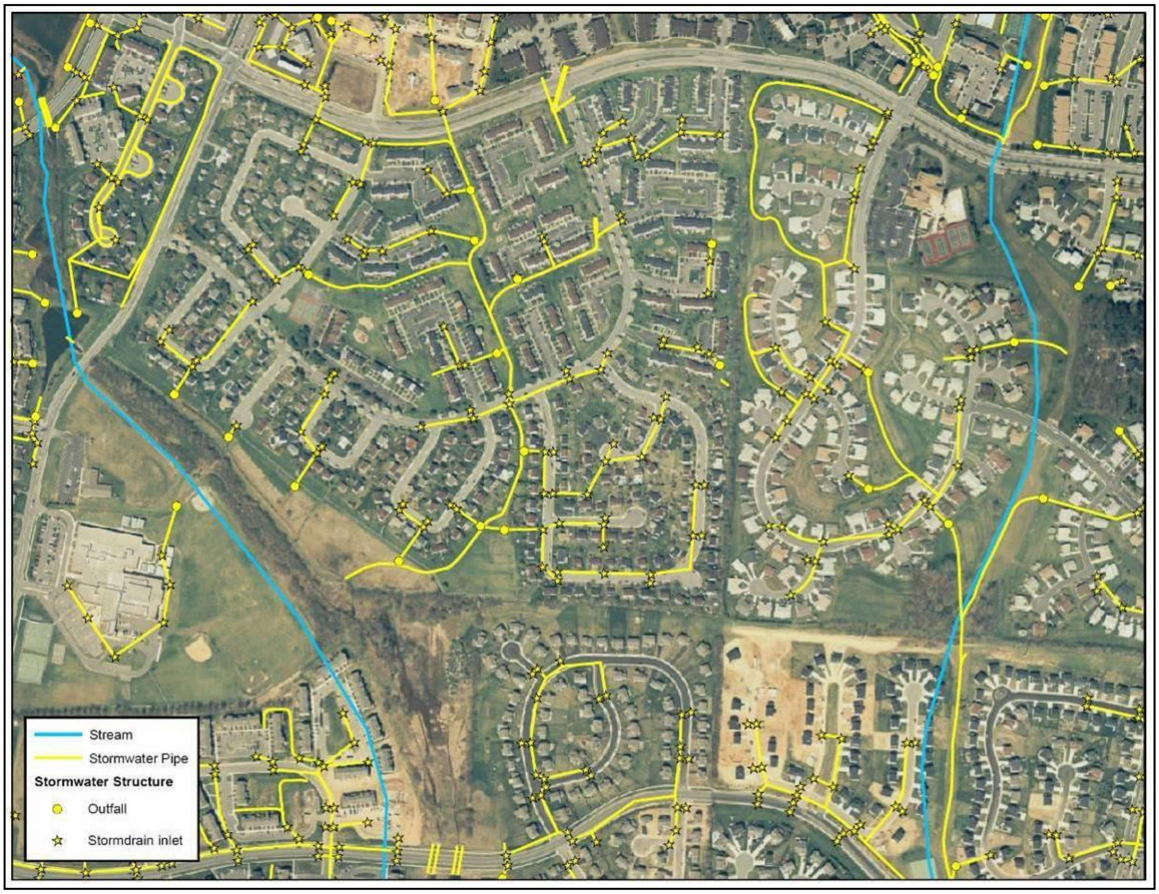


Figure 2-3. Example of orthophotography (March 2000) and stormwater conveyance features used in conjunction with other GIS data (see Figure 2-2) to help identify potential stormwater retrofit and stream restoration opportunities in Ballenger Creek watershed. This image shows the area located in the center of Figure 2-2.

In part, Versar's project team of engineers and environmental scientists utilized mapped information from the SCA and aerial photographs to identify impacted stream reaches. Once an impacted area was identified and opportunities for improvement were noted, the project team looked to upstream or nearby upland areas to evaluate potential causes of the impacts. Potential improvements to these upstream/upland areas that could alleviate downstream stresses were also noted.

2.3 WORKSHOP TO GATHER PUBLIC INPUT

A public workshop was held on April 21, 2005 at Ballenger Creek Elementary School to provide an overview of the County's study, identify public concerns (e.g., frequent flooding, poor aesthetics, pollution, etc.), and solicit public input for identification of restoration and SWM opportunities. Meeting announcement and presentation materials have been included in the Appendix. The meeting was attended by County staff, Community Restoration partners, and a moderate turnout of private citizens. Meeting attendants were receptive to the general types of restoration and retrofit approaches presented at the meeting. In addition, meeting attendants made a number of suggestions, as summarized in Table 2-3. Issues and opportunities obtained from the public were examined by the project team, and incorporated into the map review and project identification process.

Table 2-3. Summary of comments received at the April 21, 2005 public meeting

Suggestion Number	Description of Problem	Associated Candidate Projects
101	Ballenger Creek below Ballenger Creek Pike – Land erosion banks of creek	5-13
201	Country Side Subdivision, MD 85 and Cypress Court – stormwater management issues	5-16
202	Ballenger Creek below New Design Road – High erosion, flooding every rain, loss of property – approx. 20 ft.	5-17
301	Ballenger Creek and Jefferson Pike – After every heavy rain, brown storm water runs rapidly down Jefferson Pike and empties into Ballenger Creek	4-6
302	Ballenger Creek below Jefferson Pike – Cows have access to stream. Last fall, the farmer put up electric fence limiting access to a small area, but he still mows up to the stream edge.	4-7
303	Woodhill Way and Woodhurst Drive – Riprap put in between Lot 2 and Lot 1. Does not work – bad erosion and funneling water toward creek, have also seen 3' diameter trees floating downstream on high flow	4-15
304	Unnamed Tributary below Jefferson Pike, west of Renn Road – Debris and dead trees; drain pipe under Rte. 180 several feet above creek creating pool and rapid overflow and water does not go down creek; creek has moved outside original banks, cutting new channel (near Jefferson Pike); high flow from 2 branches of stream above; water appears to be from upstream of Jefferson Pike (not from the road itself); flooding also affects Stillwater horse farm next door; some trees were planted under Forest Conservation, landowner asked what permission is needed if must remove to access stream for debris removal. Resident provided 4 photos of problem area in wet weather conditions.	4-11, 4-10, 4-15, 4-12, 4-13, 4-14, 4-16

2.4 FIELD VISITS

To further evaluate opportunities for watershed improvement and collect data to support the identification of candidate restoration sites, Versar staff conducted detailed visual inspections of many of the identified candidate sites in May through July 2005. During these site visits, the project team evaluated factors such as existing stormwater management structures and other BMPs, site drainage pathways, property ownership and uses, site layout for locating new controls, utilities and other site constraints, land uses for potential water pollution sources, hydraulic/hydrologic problems, stressed vegetation, and stream stability to identify specific improvement opportunities.

2.5 PRIORITIZATION OF CANDIDATE PROJECTS

Seventy-four candidate project sites were identified in the preceding steps of this project. While many of these opportunities have been identified as localized points, a number represent more linear opportunities (Figure 2-4). Once candidate sites had been identified, Versar engaged in an in-depth process for prioritizing potential candidate projects in the watershed.

The prioritization process was similar to that employed in Lower Bush Creek Watershed (Perot et al. 2003), with minor modifications to incorporate data from the SCA and evaluate different types of projects within the same framework (e.g., stormwater retrofits vs. stream restoration). A prioritization ranking method was developed using categories of potential non-point source site problems, point source water quality and habitat site problems, and physical and cultural geographic considerations. Non-point source water quality problems were ranked based on the site's potential to contribute excessive runoff volume or rate, to contribute excessive sediment load, and to deliver pollutants to the flow. Potential point source water quality and habitat site problems were ranked and include pipe outfalls, exposed pipes, site specific bank erosion, channel alteration, fish barriers, site specific inadequate riparian buffer, and generally poor habitat conditions. Physical and cultural geographic considerations - geographic extent of the problem, educational impact, expressed citizen concerns - were also ranked.

In general, a three-point numerical rating was assigned to each criteria, with 1 being low and 3 being high; with a higher score resulting in a greater priority for implementation. While Moderate, Severe, and Very Severe scores from the SCA ratings were assigned a 1, 2, or 3, respectively, scores for Geographic Considerations were assigned as follows:

- Relative extent of the problem (Extent) – localized problems = 1; widespread = 3
- Opportunity for Educational Benefits (relative number of individuals that would be exposed to educational aspects of the project) – minor (e.g., a few individuals) = 1; major (e.g., large number of individuals/groups) = 3
- Citizen’s Concern (project addresses citizen input received at public workshop and during course of project) – minor improvement of concern = 1; major improvement of concern = 3.

Based on these ratings, category totals were then adjusted according to the percent weight and rank numbers listed in Table 2-4. Each candidate project site was given a score out of 100%.

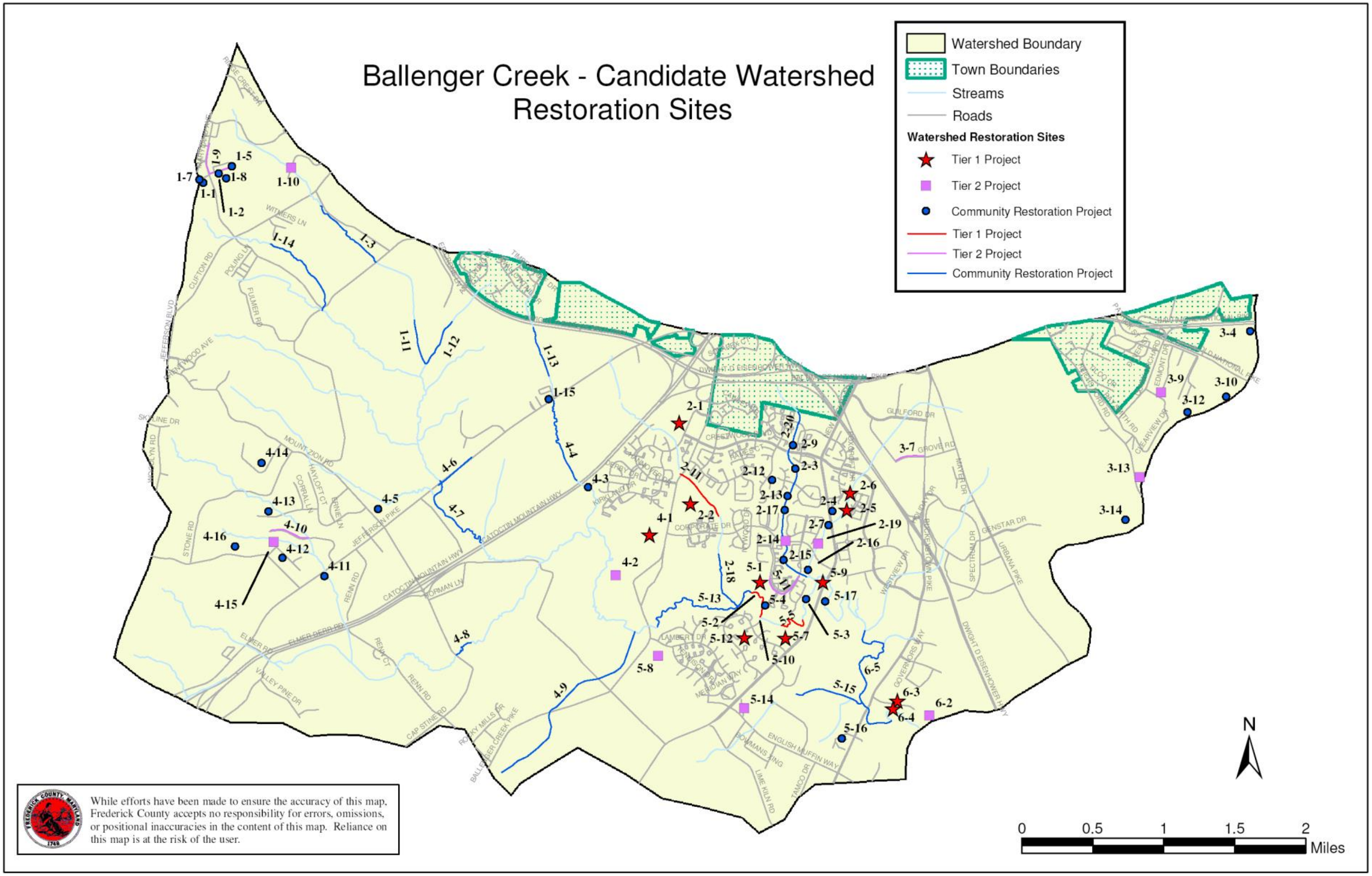


Figure 2-4. Location of candidate watershed restoration projects in Ballenger Creek Watershed

Table 2-4. Summary of Candidate Project Site Prioritization Weighting and Ranks				
Prioritization Categories and Sub-Categories	**Percent Weight**	**Number of Sites in Rank**		
		1 *(Moderate)*	**2** *(Severe)*	**3** *(Very Severe)*
Non-Point Source Site Problems	25			
Runoff Volume and Rate		16	22	17
Sedimentation		15	21	8
Pollutants		20	46	7
Point Source and Habitat Site Problems	25			
Bank Erosion		7	4	3
Exposed Pipe		0	0	1
Pipe Outfall		0	5	7
Inadequate Riparian Buffer		4	4	11
Fish Barrier		3	2	6
Habitat Condition		0	2	0
Channel Alteration		2	1	3
Geographic Considerations		*(Low)*	*(Moderate)*	*(High)*
Extent	20	27	27	20
Educational Benefit	20	27	32	15
Citizen's Concern	10	0	5	7
Total	100			

Subsequently, in consideration of the County's ownership and other requirements for the best opportunities to address urban stormwater impacts (Section 1.2), we divided the 74 sites into the following two groups: CIP projects and Community Restoration (CR) projects. Based on this division, 29 sites were categorized as CIP projects and 45 as CR projects.

Ownership information on these sites was reviewed using a combination of on-line real property databases maintained by the state and a review of records in the County Courthouse. While ownership of some properties was relatively straightforward to identify, determining ownership of a number of properties was more complex. For example, community open space is frequently dedicated to the County by the developers, but the transfer of ownership is not complete until it has been recorded by the County. This process has only been completed for some of the dedicated land within the watershed. Given the complexity of ownership and the potential for changes in ownership over time, this property ownership information should be considered preliminary and should be verified before initiating projects at these locations. Ownership for the 29 candidate CIP sites is summarized in Table 2-5.

The list of 29 candidate CIP projects was further reviewed to narrow the list to the best opportunities for implementation. Review of the Total Scores for candidate CIP projects identified an apparent natural break in scores between 41% and 44%. As such, the 15 sites that received a score greater than 44% are considered the best opportunities for implementation and have been identified as Tier I sites. Individual fact sheets are presented in Section 4.1 for these 15 Tier I sites. The remaining 14 candidate CIP sites, which still present good opportunities for watershed restoration are placed into a Tier II list of sites and are summarized in Section 4.2. The 45 CR sites are summarized in Section 4.3. Tables 2-6 and 2-7 list all sites by CIP or CR status, site number, and prioritization score.

Table 2-5. Summary of ownership for the candidate CIP project sites

Ownership	Tier 1	Tier 2	Total
Frederick County Board of Education	4	2	6
Frederick County Department of Highways and Transportation	0	10	10
Frederick County Department of Parks and Recreation	2	0	2
Frederick County Division of Utilities and Solid Waste Management	1	1	2
Frederick County Sheriff's Office - Corrections Bureau	1	0	1
Dedicated, but not necessarily deeded, to Frederick County	5	0	5
Mix of land owned by Frederick County and private owners	2	1	3

Table 2-6. Summary and ranking of candidate CIP watershed restoration opportunities in Ballenger Creek, Frederick County, MD. Tier I sites represent the best opportunity for watershed improvements.

			Severity of Site Problems					Severity of Downstream Problems (SCA)									Extent of Problem			Educational Benefit			Citizen Concern			
	Site No.	Total Score (max. 100)	Flow	Sediment	Pollutants	*Subtotal (max. 9)*	Weighted Category Score (max. 25)	Bank Erosion	Channel Alteration	Inadequate Buffer	Exposed Pipe	Pipe Outfall	Fish Barrier	Habitat Condition	*Subtotal (max. 21)*	Weighted Category Score (max. 25)	Relative extent of problem widespread = 3 localized = 1	*Subtotal (max. 3)*	Weighted Category Score (max. 20)	Opportunity for benefit major = 3 minor = 1	*Subtotal (max. 3)*	Weighted Category Score (max. 20)	Addresses meeting input major = 3 minor = 1	*Subtotal (max. 3)*	Weighted Category Score (max. 10)	Site Notes
Tier I Sites	5-5	**68**	3	3	2	*8*	**22**	3						2	*5*	**6**	3	*3*	**20**	3	*3*	**20**		*0*	**0**	Mainstem near Ballenger Cr. Trail loop
	2-11	**64**	3	3	1	*7*	**19**	1	3						*4*	**5**	3	*3*	**20**	3	*3*	**20**		*0*	**0**	Pike Branch behind Ballenger Cr. Middle Sch.
	5-10	**60**	1	3	2	*6*	**17**		3						*3*	**4**	3	*3*	**20**	3	*3*	**20**		*0*	**0**	Ballenger Cr. Elementary School - Reach 2
	5-2	**60**	1	3	2	*6*	**17**		3						*3*	**4**	3	*3*	**20**	3	*3*	**20**		*0*	**0**	Ballenger Cr. Elementary School - Reach 1
	2-2	**57**	3	0	3	*6*	**17**								*0*	**0**	3	*3*	**20**	3	*3*	**20**		*0*	**0**	Ballenger Creek Middle School
	4-1	**54**	2	1	2	*5*	**14**								*0*	**0**	3	*3*	**20**	3	*3*	**20**		*0*	**0**	Ballenger Creek Park
	5-1	**53**	3	1	3	*7*	**19**								*0*	**0**	2	*2*	**13**	3	*3*	**20**		*0*	**0**	Ballenger Creek Elementary School
	5-7	**53**	3	1	3	*7*	**19**								*0*	**0**	2	*2*	**13**	3	*3*	**20**		*0*	**0**	Ballenger Cr. Trail - loop and parking area
	6-3	**49**	3	3	3	*9*	**25**					3			*3*	**4**	2	*2*	**13**	1	*1*	**7**		*0*	**0**	Adult Detention Center
	6-4	**49**	3	3	3	*9*	**25**					3			*3*	**4**	2	*2*	**13**	1	*1*	**7**		*0*	**0**	Dept. Utilities & Solid Waste Mgmt. office
	5-12	**47**	3	0	2	*5*	**14**								*0*	**0**	3	*3*	**20**	2	*2*	**13**		*0*	**0**	Robin Meadows Subdivision
	2-5	**46**	2	0	2	*4*	**11**						1		*1*	**1**	3	*3*	**20**	2	*2*	**13**		*0*	**0**	Frederick Village Subdivision
	2-6	**46**	2	0	2	*4*	**11**						1		*1*	**1**	3	*3*	**20**	2	*2*	**13**		*0*	**0**	Foxcroft II Subdivision
	2-1	**44**	2	1	1	*4*	**11**								*0*	**0**	2	*2*	**13**	3	*3*	**20**		*0*	**0**	Orchard Grove Elementary School
	5-9	**44**	2	0	2	*4*	**11**								*0*	**0**	2	*2*	**13**	3	*3*	**20**		*0*	**0**	Ballenger Cr. Trail above New Design Road
Tier II Sites	4-10	**41**	3	0	1	*4*	**11**			1			2		*3*	**4**	1	*1*	**7**	2	*2*	**13**	2	*2*	**7**	Wye Creek Dr. - LID in road rights-of-way
	2-14	**41**	2	0	2	*4*	**11**					3			*3*	**4**	2	*2*	**13**	2	*2*	**13**		*0*	**0**	King Br. at Corporate Dr. - culvert retrofit
	3-13	**41**	2	1	2	*5*	**14**								*0*	**0**	2	*2*	**13**	2	*2*	**13**		*0*	**0**	Reichs Ford Rd. - old roadbed
	4-15	**39**	3	0	1	*4*	**11**			2			2		*4*	**5**	1	*1*	**7**	1	*1*	**7**	3	*3*	**10**	Woodhill Way at Woodhirst Dr. - road LID
	4-2	**39**	1	0	1	*2*	**6**								*0*	**0**	2	*2*	**13**	3	*3*	**20**		*0*	**0**	Tuscarora High School
	5-8	**39**	1	0	1	*2*	**6**								*0*	**0**	2	*2*	**13**	3	*3*	**20**		*0*	**0**	Tuscarora Elementary School
	5-11	**38**	2	0	2	*4*	**11**								*0*	**0**	1	*1*	**7**	3	*3*	**20**		*0*	**0**	Kingsbrook Drive near Ballenger Cr. Elem. Sch.
	1-10	**38**	2	0	2	*4*	**11**								*0*	**0**	2	*2*	**13**	2	*2*	**13**		*0*	**0**	Running Springs Court - road rights-of-way
	3-9	**38**	1	0	3	*4*	**11**								*0*	**0**	2	*2*	**13**	2	*2*	**13**		*0*	**0**	Clearview Detention Pond - retrofit
	2-19	**36**	2	0	2	*4*	**11**			1		3			*4*	**5**	1	*1*	**7**	2	*2*	**13**		*0*	**0**	Arundel Br. above Corp. Dr. - road rights-of-way
	6-2	**27**	3	0	2	*5*	**14**								*0*	**0**	1	*1*	**7**	1	*1*	**7**		*0*	**0**	Ballenger Cr. Waste Water Treatment Plant
	1-9	**26**	1	0	1	*2*	**6**								*0*	**0**	1	*1*	**7**	2	*2*	**13**		*0*	**0**	Maryland Ave. - road rights-of-way
	3-7	**26**	1	0	1	*2*	**6**								*0*	**0**	1	*1*	**7**	2	*2*	**13**		*0*	**0**	Grove Road - road rights-of-way
	5-14	**16**	1	0	0	*1*	**3**								*0*	**0**	1	*1*	**7**	1	*1*	**7**		*0*	**0**	English Muffin Way - old roadbed

Weighted Category Score = (Subtotal/Maximum Possible Subtotal) * Weighting Factor

Total Score (max = 100) = Severity of Site Problems (Wt. = 25%) + Severity of Downstream Problems (Wt. = 25%) + Extent of Problem (Wt. = 20%) + Educational Benefit (Wt. = 20%) + Citizen Concern (Wt. = 10%)

Table 2-7. Summary and ranking of candidate CR watershed restoration opportunities in Ballenger Creek, Frederick County, MD (note that UT = Unnamed Tributary)

Community Restoration Opportunities

		Severity of Site Problems					Severity of Downstream Problems (SCA)									Extent of Problem			Educational Benefit			Citizen Concern			
Site No.	Total Score (max. 100)	Flow	Sediment	Pollutants	*Subtotal (max. 9)*	Weighted Category Score (max. 25)	Bank Erosion	Channel Alteration	Inadequate Buffer	Exposed Pipe	Pipe Outfall	Fish Barrier	Habitat Condition	*Subtotal (max. 21)*	Weighted Category Score (max. 25)	Relative extent of problem widespread = 3 localized = 1	*Subtotal (max. 3)*	Weighted Category Score (max. 20)	Opportunity for benefit major = 3 minor = 1	*Subtotal (max. 3)*	Weighted Category Score (max. 20)	Addresses meeting input major = 3 minor = 1	*Subtotal (max. 3)*	Weighted Category Score (max. 10)	Site Notes
2-9	**59**	3	2	2	*7*	**19**			3		2			*5*	**6**	3	*3*	**20**	2	*2*	**13**		*0*	**0**	King Branch - Reach 1
2-13	**58**	3	1	2	*6*	**17**		1	3	3				*7*	**8**	3	*3*	**20**	2	*2*	**13**		*0*	**0**	King Branch - Reach 3
2-3	**57**	3	1	2	*6*	**17**		1	3		2			*6*	**7**	3	*3*	**20**	2	*2*	**13**		*0*	**0**	King Branch - Reach 2
5-3	**57**	3	3	2	*8*	**22**	3		2		2			*7*	**8**	1	*1*	**7**	3	*3*	**20**		*0*	**0**	Ballenger Creek at Duke Court
2-20	**56**	3	1	1	*5*	**14**		2	3		2			*7*	**8**	3	*3*	**20**	2	*2*	**13**		*0*	**0**	King Branch stream restoration
4-14	**56**	2	1	2	*5*	**14**	1		3			3		*7*	**8**	2	*2*	**13**	2	*2*	**13**	2	*2*	**7**	Mount Zion Estates Subdivision
4-12	**54**	2	1	2	*5*	**14**			3			3		*6*	**7**	2	*2*	**13**	2	*2*	**13**	2	*2*	**7**	Brentwood Subdivision
4-13	**54**	2	1	2	*5*	**14**			3			3		*6*	**7**	2	*2*	**13**	2	*2*	**13**	2	*2*	**7**	Hillside Estates I Subdivision
4-16	**54**	2	1	2	*5*	**14**			3			3		*6*	**7**	2	*2*	**13**	2	*2*	**13**	2	*2*	**7**	Fogles Delt-Chas Subdivision
4-11	**49**	3	2	2	*7*	**19**								*0*	**0**	2	*2*	**13**	1	*1*	**7**	3	*3*	**10**	UT below Jefferson Pike, W of Renn Rd
2-17	**48**	0	2	2	*4*	**11**					3			*3*	**4**	3	*3*	**20**	2	*2*	**13**		*0*	**0**	King Branch - buffer/wildflowers
5-13	**48**	0	2	2	*4*	**11**								*0*	**0**	3	*3*	**20**	1	*1*	**7**	3	*3*	**10**	Ballenger Creek above Pike Branch
4-4	**46**	0	3	1	*4*	**11**	1		3			3		*7*	**8**	3	*3*	**20**	1	*1*	**7**		*0*	**0**	Butterfly Branch above US 15/340
2-15	**44**	2	0	2	*4*	**11**								*0*	**0**	3	*3*	**20**	2	*2*	**13**		*0*	**0**	Ballenger Crossing Subdivision
5-16	**44**	2	1	2	*5*	**14**								*0*	**0**	1	*1*	**7**	2	*2*	**13**	3	*3*	**10**	Country Side Subdivision
4-7	**43**	0	2	2	*4*	**11**	2							*2*	**2**	2	*2*	**13**	1	*1*	**7**	3	*3*	**10**	Ballenger Creek E of Feagaville Rd.
1-15	**41**	2	0	2	*4*	**11**					3			*3*	**4**	2	*2*	**13**	2	*2*	**13**		*0*	**0**	Jefferson Blvd - road rights-of-way
4-6	**41**	2	0	2	*4*	**11**								*0*	**0**	1	*1*	**7**	2	*2*	**13**	3	*3*	**10**	Jefferson Pike at Ballenger Creek
5-17	**41**	2	2	1	*5*	**14**	3							*3*	**4**	1	*1*	**7**	1	*1*	**7**	3	*3*	**10**	Ballenger Cr. below New Design Road
1-2	**40**	2	0	2	*4*	**11**	2							*2*	**2**	1	*1*	**7**	3	*3*	**20**		*0*	**0**	Braddock Heights Post Office
4-9	**40**	0	2	2	*4*	**11**			2					*2*	**2**	3	*3*	**20**	1	*1*	**7**		*0*	**0**	UT along Ballenger Cr. Pike and Elmer Derr Rd.
2-4	**39**	1	0	2	*3*	**8**					2	1		*3*	**4**	2	*2*	**13**	2	*2*	**13**		*0*	**0**	Frederick Village Subdivision
3-14	**38**	0	2	2	*4*	**11**								*0*	**0**	3	*3*	**20**	1	*1*	**7**		*0*	**0**	Monocacy River below Reichs Ford Rd
6-5	**38**	0	2	2	*4*	**11**								*0*	**0**	3	*3*	**20**	1	*1*	**7**		*0*	**0**	Mainstem S of Westview Corporate Campus
2-12	**38**	2	0	2	*4*	**11**								*0*	**0**	2	*2*	**13**	2	*2*	**13**		*0*	**0**	Honeysuckle Court
2-7	**36**	1	0	1	*2*	**6**			3					*3*	**4**	2	*2*	**13**	2	*2*	**13**		*0*	**0**	Arundel Br. below New Design Rd.
4-3	**35**	2	0	1	*3*	**8**			3			3		*6*	**7**	1	*1*	**7**	2	*2*	**13**		*0*	**0**	Butterfly Branch at Rainier Dr.
1-12	**35**	0	2	2	*4*	**11**			1				2	*3*	**4**	2	*2*	**13**	1	*1*	**7**		*0*	**0**	UT below Ed Crone Lane
1-3	**33**	0	2	2	*4*	**11**	2							*2*	**2**	2	*2*	**13**	1	*1*	**7**		*0*	**0**	UT next to Gold Mine Road
1-14	**32**	0	2	2	*4*	**11**	1							*1*	**1**	2	*2*	**13**	1	*1*	**7**		*0*	**0**	UT at Cedarwood Terrace
3-4	**31**	0	2	2	*4*	**11**								*0*	**0**	1	*1*	**7**	2	*2*	**13**		*0*	**0**	Monocacy River at Driving Range
3-10	**31**	0	2	2	*4*	**11**								*0*	**0**	2	*2*	**13**	1	*1*	**7**		*0*	**0**	Monocacy River below MD 40
2-18	**31**	0	2	1	*3*	**8**	2							*2*	**2**	2	*2*	**13**	1	*1*	**7**		*0*	**0**	Pike Branch above Ballenger Creek
1-1	**29**	1	0	1	*2*	**6**	1		2					*3*	**4**	1	*1*	**7**	2	*2*	**13**		*0*	**0**	Braddock Hts Vol. Fire Co
2-16	**29**	1	0	1	*2*	**6**					3			*3*	**4**	1	*1*	**7**	2	*2*	**13**		*0*	**0**	Arundel Branch at Mawes Court
1-11	**26**	0	2	2	*4*	**11**			1					*1*	**1**	1	*1*	**7**	1	*1*	**7**		*0*	**0**	UT below Mount Phillip Road
1-13	**26**	0	2	2	*4*	**11**	1							*1*	**1**	1	*1*	**7**	1	*1*	**7**		*0*	**0**	Butterfly Branch above Jefferson Pike
4-8	**26**	0	2	2	*4*	**11**	1							*1*	**1**	1	*1*	**7**	1	*1*	**7**		*0*	**0**	Renn Branch below Cap Stine Rd
1-5	**26**	1	0	1	*2*	**6**								*0*	**0**	1	*1*	**7**	2	*2*	**13**		*0*	**0**	Braddock Heights Community Assoc.
3-12	**24**	0	2	2	*4*	**11**								*0*	**0**	1	*1*	**7**	1	*1*	**7**		*0*	**0**	Monocacy River at River View Court
5-15	**24**	0	2	2	*4*	**11**								*0*	**0**	1	*1*	**7**	1	*1*	**7**		*0*	**0**	UT in Russell Business Park
5-4	**24**	1	2	1	*4*	**11**								*0*	**0**	1	*1*	**7**	1	*1*	**7**		*0*	**0**	Ballenger Cr. at Bamburg Court
1-7	**22**	0	0	3	*3*	**8**								*0*	**0**	1	*1*	**7**	1	*1*	**7**		*0*	**0**	Jefferson Blvd - trash cleanup
1-8	**22**	1	1	1	*3*	**8**								*0*	**0**	1	*1*	**7**	1	*1*	**7**		*0*	**0**	Braddock Heights water tower
4-5	**22**	1	1	1	*3*	**8**								*0*	**0**	1	*1*	**7**	1	*1*	**7**		*0*	**0**	UT at Saddle Court

Weighted Category Score = (Subtotal/Maximum Possible Subtotal) * Weighting Factor

Total Score (max = 100) = Severity of Site Problems (Wt. = 25%) + Severity of Downstream Problems (Wt. = 25%) + Extent of Problem (Wt. = 20%) + Educational Benefit (Wt. = 20%) + Citizen Concern (Wt. = 10%)

3.0 WATERSHED RESTORATION APPROACHES

Addressing the effects of urbanization on watersheds can be a challenging issue, primarily because traditional stormwater management approaches can be difficult to build into a built-out environment. Often, site constraints such as current use and space limitations, property ownership, cost, public acceptance, and long-term maintenance responsibility are barriers to effectively retrofitting SWM controls into existing urban settings.

However, a number of approaches exist that can be used individually, or in an integrated combination, to work around these challenges and provide improved stormwater controls. The following is an overview of these approaches, the details of which can been customized to meet individual site requirements, information on stormwater management issues in karst terrain, and a summary of costs associated with watershed restoration techniques.

3.1 RESTORATION OPTIONS

Watershed restoration approaches fall into five basic categories:

- **New SWM ponds** – placement of new stormwater management ponds into locations that currently have no stormwater quantity or quality controls
- **SWM pond retrofits** – modifying existing SWM ponds to provide additional quantity or quality controls
- **Low impact development (LID)** – LID approaches are innovative practices designed to mimic natural flows by reducing the volume of stormwater runoff at the source, not merely in managing flows as they leave a site. Distributed LID features are a series of smaller landscape features that function as retention/detention areas integrated into developed areas. These features are designed and constructed to detain and treat stormwater through natural processes such as infiltration, soil storage, and uptake by vegetation. For the practices noted below, special attention should be paid to the composition of existing soils, as well as new soils or amended soils used. These solutions are increasingly being used to reduce stormwater-related and other adverse urban environmental impacts in developed areas (in addition to their incorporation into new development).
- **Stream restoration –** physical modifications to stream channels, banks, and instream habitat to repair to improve degraded and unstable conditions
- **Buffer enhancement –** replanting streamside vegetation with native species to improve the vegetated community, which buffer, or insulate, streams from a wide range of land use stressors

Additional information on these approaches follow.

3.1.1 New Stormwater Ponds

Description: Creation of a new stormwater pond to provide detention and water quality controls in areas were a pond does not currently exist. While sufficient space for this option may be difficult to obtain in built-out settings, the resulting benefits to flow volume and velocity control, and water quality improvement can be significant. Benefits may vary depending on the specific design features of the individual ponds.

Maintenance: The maintenance requirements of traditional stormwater ponds are well known. A typical pond is inspected by County personnel trained in dam safety and pond maintenance, looking at the dam, pipes, and riser structure to ensure it is functioning properly and not failing. Additional items that need to be inspected are any pretreatment facilities for clogging by sediments and large debris items. If sediments or clogging is evident, the area needs to be cleaned.

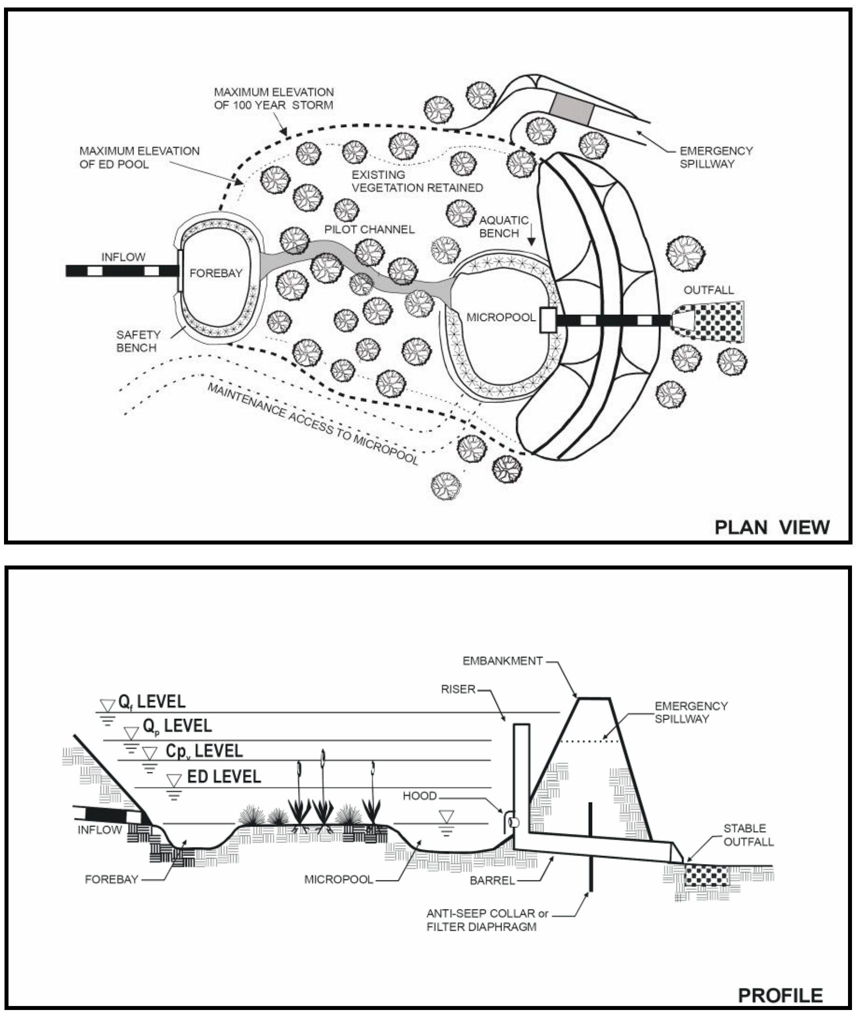


Figure 3-1. New Stormwater Pond (“Micropool” Extended Detention Pond shown)
(Source: MDE 2000a)

3.1.2 Stormwater Pond Retrofit

Description: Options for retrofitting existing SWM ponds (AMEC 2005) that may be suitable for implementation include:

1. Increasing detention storage by means of additional excavation and grading.
2. Providing water quality improvements to facilities that currently only provide water quantity control. These facilities could be retrofitted to also provide water quality treatment by means of installing a micropool, sediment forebay, constructed stormwater wetlands, or by increasing the surrounding riparian buffer.
3. Modifying or replacing the existing riser structure and outlet controls to further reduce the discharge rate from the storm water management facility. A riser is a structure, typically made of concrete with a metal grate on top, which controls the level of water in the stormwater pond.
4. Adding infiltration features such as sand filters or bioretention to promote greater peak flow reduction, groundwater recharge, and improve water quality treatment. A soil survey of the existing facility would be required to verify that this retrofit is suitable. Stormceptors, or equivalent LID products, could be installed in parking lots or other areas with a large percentage of impervious area. These devices are placed in the manhole and trap sediments and petroleum products before they flow into the pond.

Maintenance: The maintenance requirements of a retrofitted pond are not significantly more than a traditional stormwater pond. A typical pond is inspected by County personnel trained in dam safety and pond maintenance, looking at the dam, pipes, and riser structure to ensure it is functioning properly and not failing. Additional items that need to be inspected are any pretreatment facilities for clogging by sediments and large debris items. If sediments or clogging is evident, the area needs to be cleaned. If manufactured LID devices are used, manufacturer's maintenance recommendations need to be followed to ensure that devices function as designed.

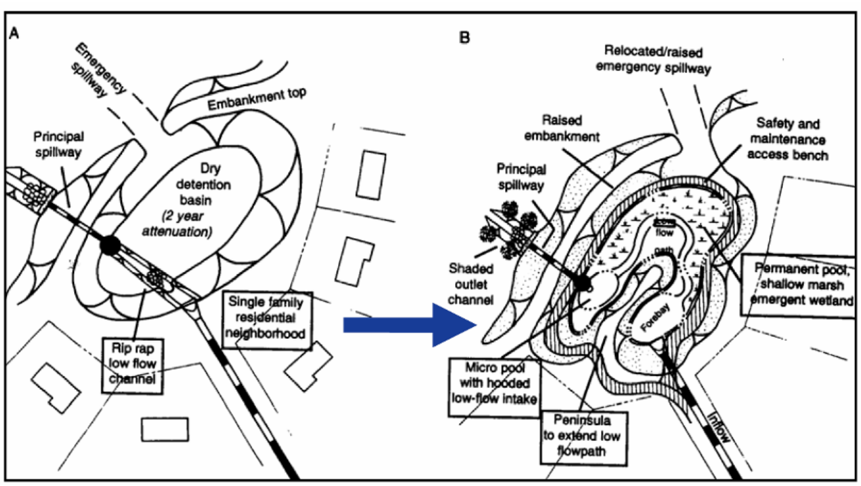


Figure 3-2. Stormwater Pond Retrofit (A. pre-retrofit pond; B. retrofitted pond)
(Source: Schueler et al. 2000)

3.1.3 Culvert Retrofit

Description: This stormwater retrofit option is installed upstream from existing road culverts by constructing a control structure and excavating a micropool. These projects are designed only for intermittent or ephemeral streams. The control structure will consist of a gabion or concrete weir that will detain and reduce stormwater flow; the micropool is a small pool that will infiltrate the first 0.1 – 0.2 inches of stormwater runoff, improving both water volume/velocity and water quality (AMEC 2005).

Maintenance: Maintenance of the micropool area is very minimal. The area needs to be inspected for large debris or sediments that may be clogging the area, dead or stressed plants, and erosion around the weir. Remove large debris, built-up sediments, and replace dead or stressed plants as necessary. If there is erosion around the weir, the area needs to be inspected and stabilized as necessary. These facilities have an expected life span of 25 years.

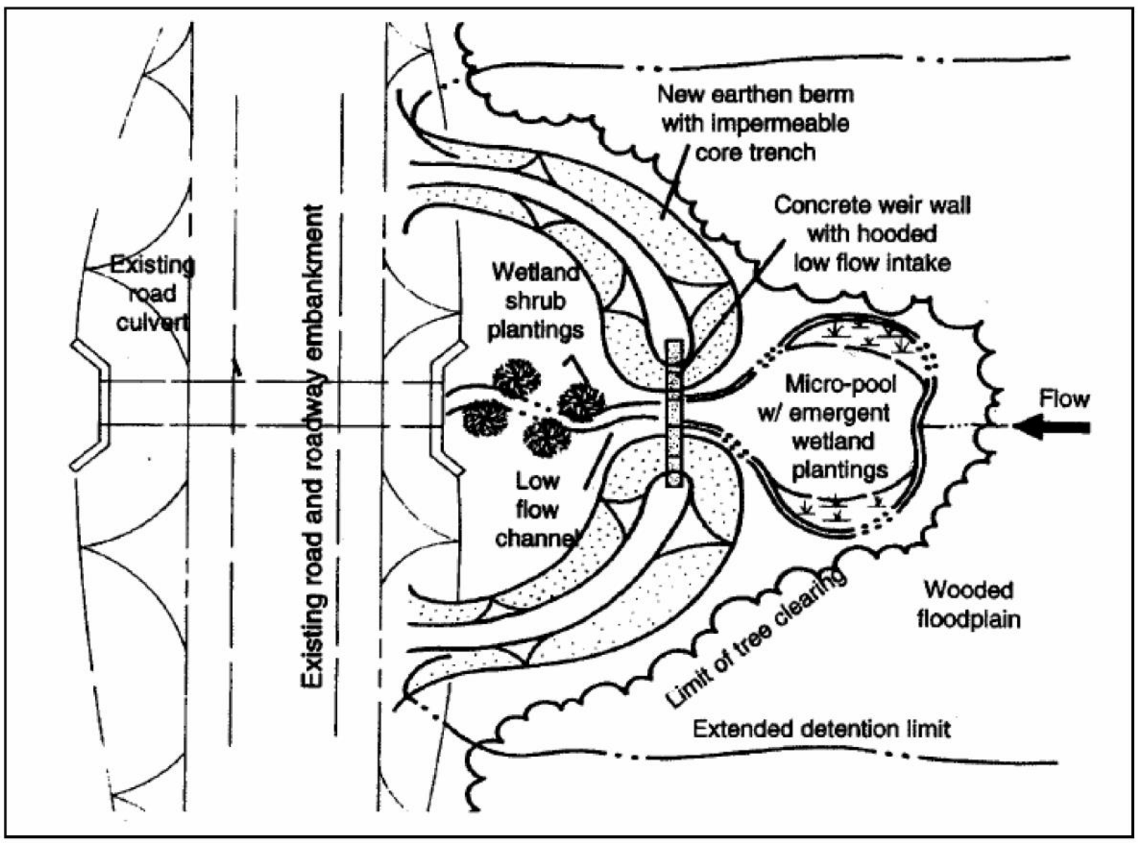


Figure 3-3. Culvert Retrofit (Source: Schueler et al. 2000)

3.1.4 Low Impact Development: Bioretention Area ("Rain Garden")

Description: Bioretention is a shallow depression utilized to detain and treat stormwater runoff from small, frequent storms by using a conditioned planting soil bed and planting materials (AMEC 2005). Pollutants are adsorbed by the soil and plant material, improving water quality. Water slowly infiltrates through the soil bed to recharge groundwater or is used by the plants via transpiration. In some cases, an underdrain system can be installed to carry treated water draining through the system to an existing stormdrain network.

Maintenance: Inspection of the treatment area's components and repair or replace as necessary. This area is akin to a landscape feature in general maintenance needs, such as removal of accumulated sediment and debris, replacement of dead or stressed plants, and annual mulching (or as necessary). These facilities have an expected life span of 25 years.

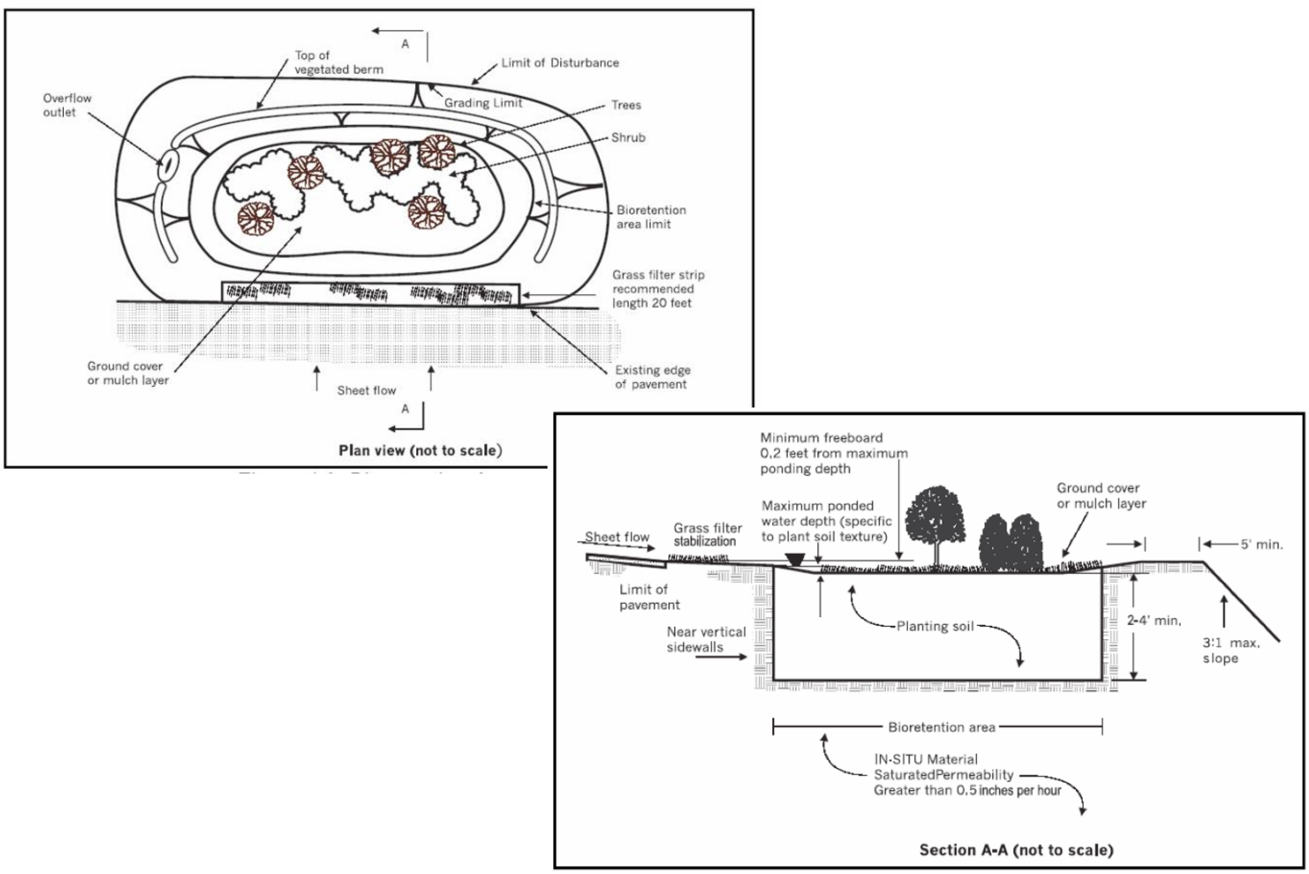


Figure 3-4. Bioretention Area (Source: Prince George's County 1999)

3.1.5 Low Impact Development: Pipe Outfall Retrofits (Off-line Bioretention)

Description: This stormwater retrofit option is installed immediately downstream of a stormwater drainage pipe outfall. Flow splitters can be utilized to convey the water quality treatment volume to a sand filter, bioretention area, off-line wetland, or wet pond, while larger storms are allowed to bypass the retrofit (AMEC 2005).

Maintenance: Inspect the treatment area's components and repair or replace as necessary. This area is akin to a landscape feature in general maintenance needs, such as removal of accumulated sediment and debris, replacement of dead or stressed plants, and annual mulching (or as necessary). An observation well can be used to make sure the underdrain is not clogged and is working properly. These facilities have an expected life span of 25 years.

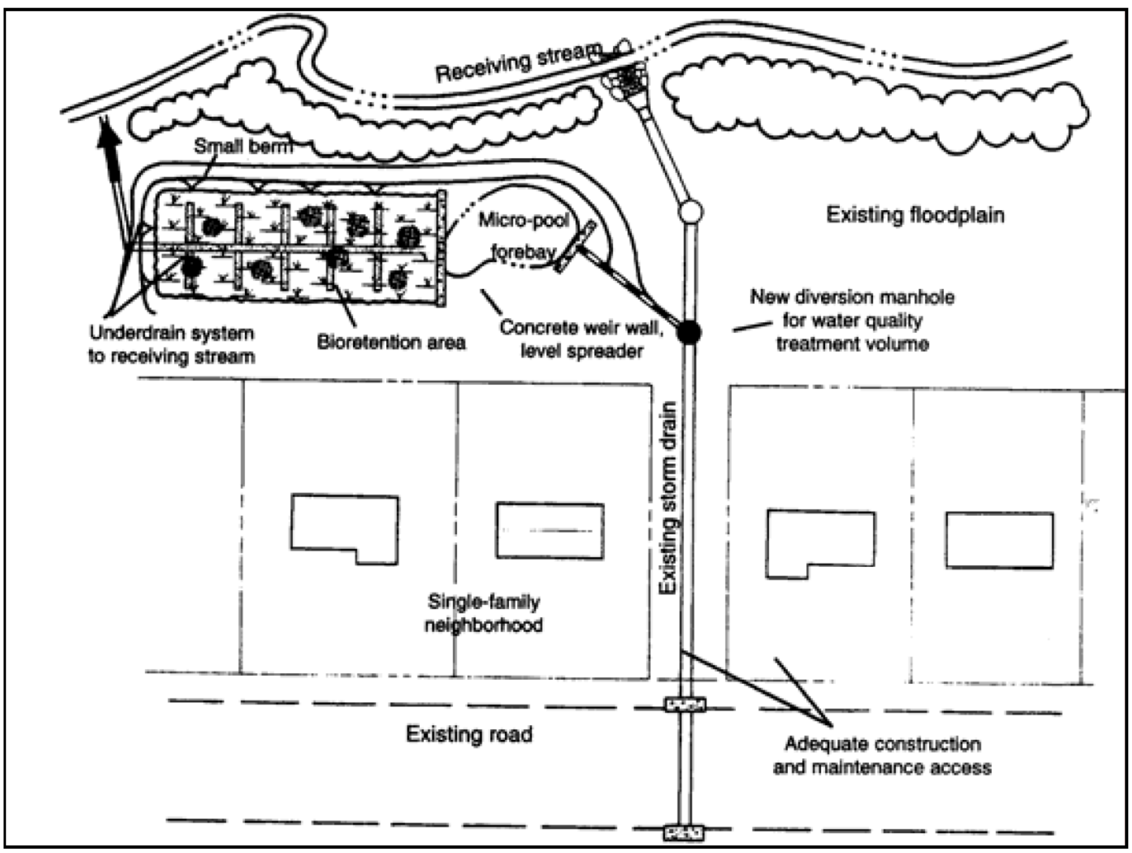


Figure 3-5. Pipe Outfall Retrofit (Source: Schueler et al. 2000)

3.1.6 Low Impact Development: Infiltration Trench

Description: An infiltration trench is an excavated trench that has been backfilled with stone to form a subsurface basin. Stormwater runoff is diverted into the trench and is stored until it can be infiltrated into the soil, usually over a period of several days. These structures are ideal for small urban drainage areas, and have a longer life cycle when some form of pretreatment to remove sediment, such as a grass swale, is included in the design. Infiltration trenches can be installed in areas adjacent to parking lots, roads, and other impermeable surfaces to capture runoff (AMEC 2005).

Maintenance: Prevent sediments and debris from accumulating on the drained area, which could enter and clog the trench. Sediment and debris removal could be performed by routine sweeping or installation of a grass filter strip or other pretreatment BMP. Maintenance of the pretreatment BMP is very important to prevent clogging. Filter strip maintenance consists of reseeding any eroded areas, and periodically mowing to a height equal or greater than the design flow height. These trenches have an expected life span of 10 years.

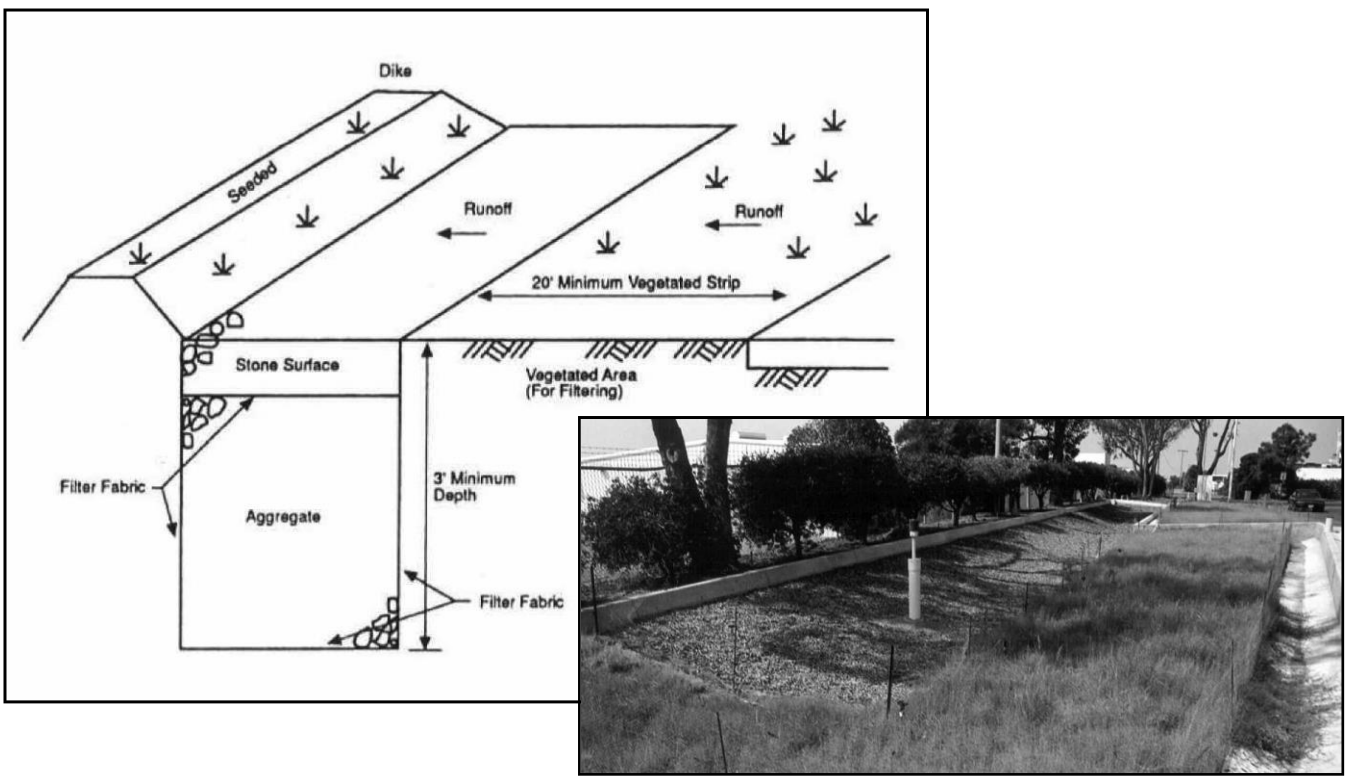


Figure 3-6. Infiltration Trench (Source: American Groundwater Trust and California Stormwater Quality Association in MAPC (Undated))

3.1.7 Low Impact Development: Grassed Swale

Description: Grassed swales provide both water quantity and quality control. Stormwater travels more slowly in a grass swale than it does in a concrete ditch, reducing runoff volume and downstream erosion (AMEC 2005). Stormwater also infiltrates into the soil, further reducing volume and removing pollutants.

Maintenance: Maintain a dense, healthy grass cover through periodic mowing, keeping grass height at or above the design flow depth. In addition, weeding, watering, reseeding of bare areas, and clearing of debris and blockages may be necessary. Swales should be inspected periodically, especially after significant rain storms to fix problems with sediment buildup and erosion. If sediment buildup occurs, sediments should be removed manually rather than with heavy machinery, which tends to reshape the swale and concentrate erosive flows. Fertilizers and pesticides should be avoided, and only used when the grass cover is diseased or dying. Compaction of the swale, from parking cars and other uses, should also be avoided. Swales have an expected life span of 25 years.

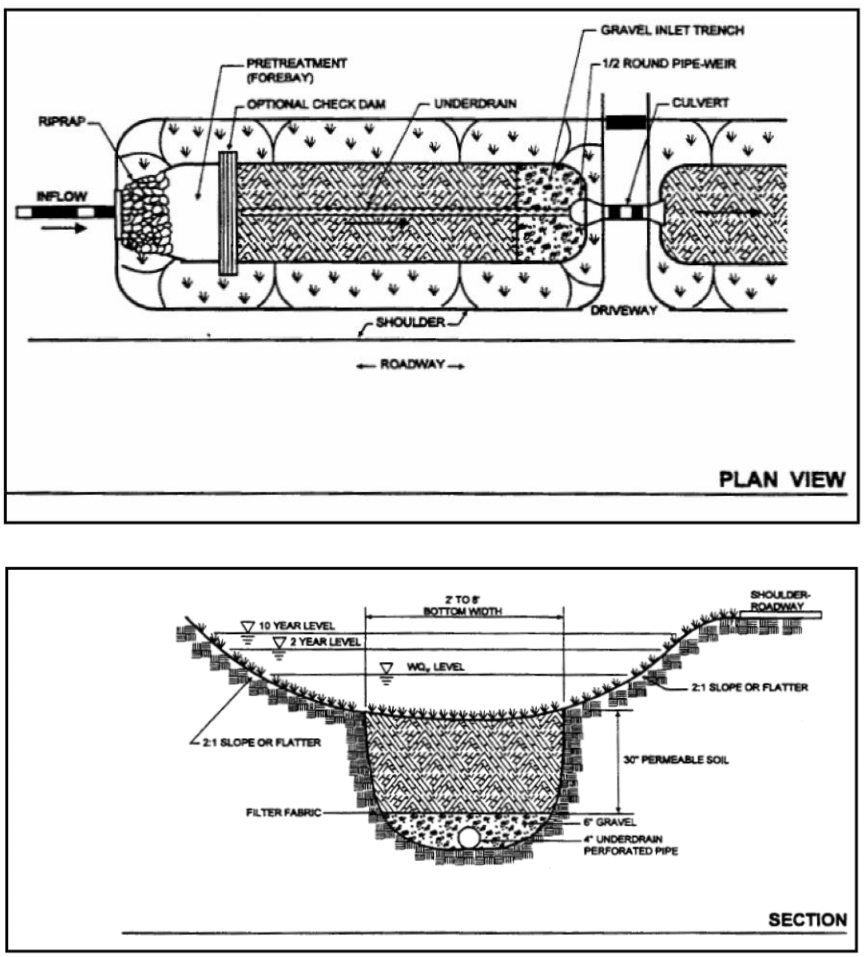


Figure 3-7. Grassed Swale (Source: Prince Georges's County 1999)

3.1.8 Low Impact Development: Manufactured LID Devices

Description: Manufactured LID devices, such as the Filterra® Stormwater Bioretention Filtration System (or a comparable alternative), allow stormwater to flow through a specially designed filter mixture contained in a landscaped concrete container (AMEC 2005). These devices are typically used to retrofit traditional storm drain inlets with a bioretention function. The filter mixture inside the device immobilizes pollutants; those pollutants are then decomposed, volatilized and incorporated into the biomass of the unit. Stormwater runoff flows through the media and into an underdrain system at the bottom of the container, where the treated water is discharged to the stormdrain network.

Maintenance: Debris and sediment removal, replacing dead or stressed plants, and mulching as necessary are the primary maintenance considerations. Most manufactured LID devices come with an observation well that is used to make sure the underdrain is not clogged and is working properly. If the system becomes clogged, the filter mixture is replaced. Additionally, most manufacturers have their own maintenance guidelines that need to be followed to maintain the performance level. Manufactured LID devices have an expected life span of 25 years.

Figure 3-8. Manufactured LID Device – Filterra® tree box insert in storm drain inlet
(Source: VA DCR 2002 and filterra.com)

3.1.9 Low Impact Development: Rain Barrels/Cisterns

Description: Rain barrels are low-cost, effective and easily maintainable retention devices that can be used in both residential and commercial/industrial sites. They are connected to downspouts and retain rooftop runoff. Rain barrels can be used to store runoff for later use in lawn and garden watering (AMEC 2005). Cisterns are larger rainwater storage containers placed either above or below ground used for watering and other non-potable uses.

Maintenance: Rain barrels and cisterns require very little maintenance. The container and attachments should be inspected for clogging several times a year and after significant storm events. Minor parts, including spigots, screens, filters, downspouts, or leaders, may require replacement. Rain barrels and cisterns have an expected life span of 25 years.

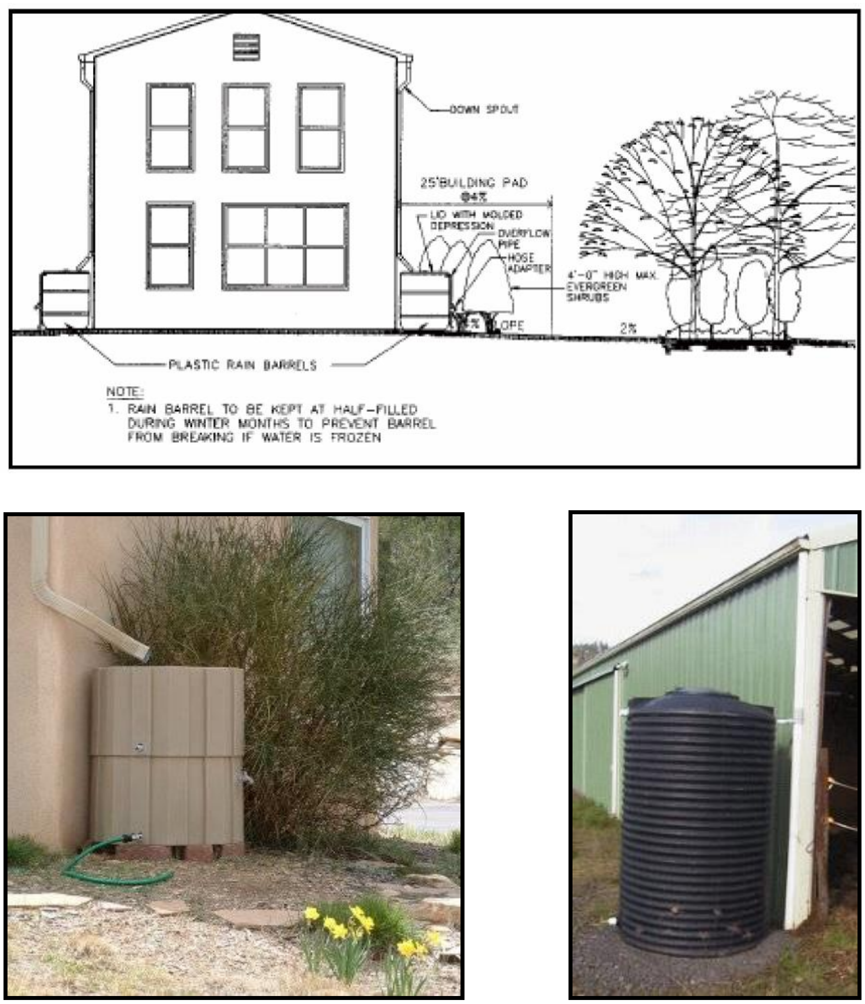


Figure 3-9. Rain barrel & above-ground cistern
(Sources: Prince Georges's County 1999; www.aridsolutions.com; and www.plastmo.com)

3.1.10 Low Impact Development: Green Roof Carport

Description: Green roof technology, consisting of a layer of soil and vegetation on top of an impervious rooftop, can be applied to carports to provide a number of benefits.

Economic Benefits –

- Increase in life expectancy of rooftop and waterproofing (2-5 times) by providing protection against temperature extremes and ultra-violet light, thereby off-setting somewhat higher up-front installation costs
- Conversion of carports to green roofs is substantially less expensive than for buildings, yet provides equal benefit per square foot of impervious surface.

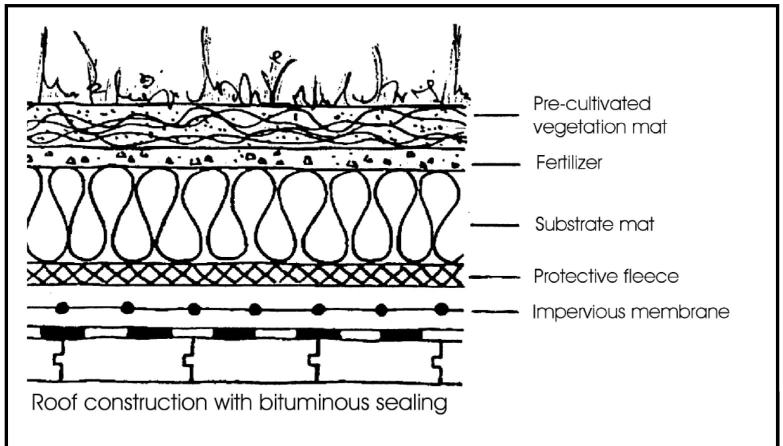


Figure 3-10. Carport with green roof
(Source: Prince Georges's County 1999)

Ecological Benefits –

- Reduce stormwater runoff (30-100% of annual rainfall can be stored, relieving stormdrains and feeder streams)
- Reduce heat island effect (cooler air temperatures and higher humidity can be achieved through natural evaporation)
- Improve Air Quality (up to 85% of dust particles can be filtered out of the air)
- New habitat for plants, insects, and birds

Amenities –

- Overhead cover provides shade to reduce interior car temperatures during hot weather, reduces need to clear snow from parked cars, and provides shelter while entering/exiting the car during inclement weather
- Reduction of noise level due to less sound reverberation and improved sound insulation
- Visible green roofs provide a more aesthetic landscape

Maintenance: Once a green roof is well established, its maintenance requirements are usually minimal. Initial watering and occasional fertilization are required until the plants have fully established themselves, and periodically thereafter during drought conditions. Periodic trimming, weeding, inspection, and plant replacement is necessary.

3.1.11 Stream Restoration/Bank Stabilization

Description: Streams damaged by erosive flows, excess sedimentation, and disruptive human activities are often not capable of re-establishing a stable form. Techniques to repair these damaged or degraded streams are now based on mimicking natural stream channels and the range of natural variability exhibited by nearby stable streams. Termed natural stream channel design, repairs focus on establishing natural stream channel shape, size, and habitat features. Restoration can range from minor repairs to restore bank stability to complete stream channel reconstruction.

Maintenance: Maintenance of natural stream channel design projects includes periodic inspection and monitoring to ensure that conditions remain within the expected range of variability. Post-construction plantings need to be monitoring to ensure that they become well-established. In addition, periodic channel adjustments may be necessary after large flow events, especially while post-construction plantings become established.

A.

B.

Figure 3-11. Stream Restoration (A. concrete lined urban channel; B. restored stream)
(Sources: M. Perot; unknown)

3.1.12 Riparian Buffer Enhancement

Description: Enhancing existing streamside vegetation by planting native varieties of trees, shrubs, and wildflowers restores many of the water quality, wildlife, and aesthetic benefits associated with riparian buffers. Vegetation filters sediments and other pollutants from stormwater runoff, moderates water temperatures in streams, improves aesthetics, and provides shelter and food to both terrestrial and stream organisms.

Maintenance: Maintenance of buffer enhancement projects includes periodic watering, removal of invasive species, and trash clean-up to ensure that plantings become well-established.

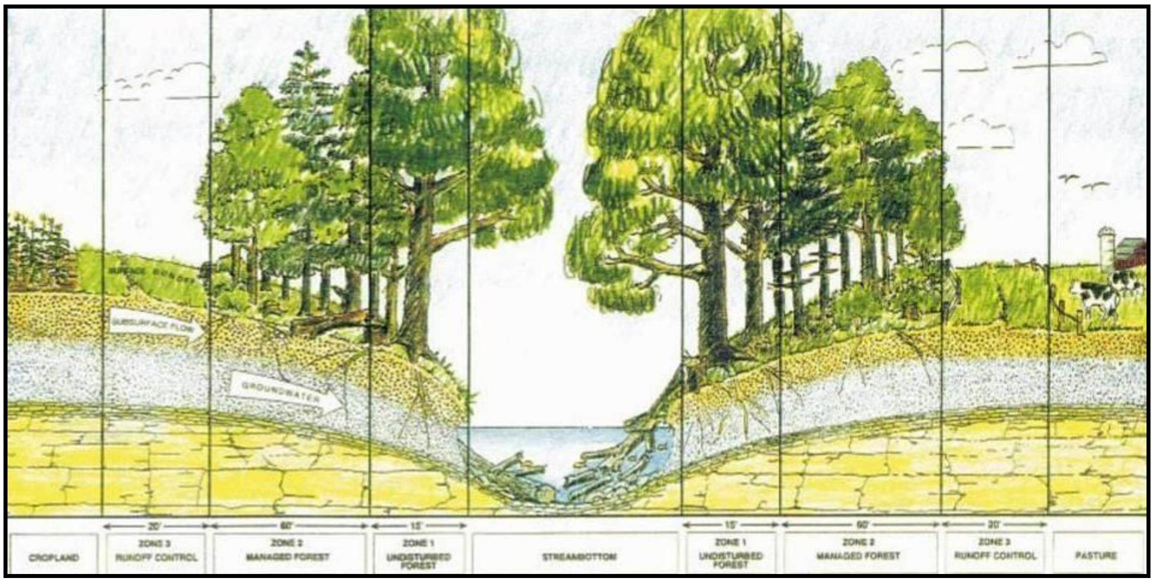


Figure 3-12. Buffer enhancement (Sources: Palone and Todd 1998; MDE 2000b; M. Southerland)

3.2 SWM IN KARST AREAS

It is widely recognized that karstic areas present a major stormwater management issue because even relatively small changes to surface features, such as landscaping, can alter run-off patterns in a way that triggers changes in karst features, such as the development of new sinkholes (Brezinski 2004). Concentrating surface runoff (e.g., into swales, SWM ponds, and other stormwater BMPs) will exacerbate the dissolution processes associated with the formation of karstic features and pose significant hazards if not properly addressed during design and construction phases (Figure 1-2). MDE recognizes these challenges and the *2000 Maryland Stormwater Design Manual* has established special requirements (e.g., liners, subsurface investigations for designs, and repair guidance) for traditional SWM facilities in karst areas to prevent and address karst problems (Appendix D.2 in MDE 2000a).

As mentioned in our previous assessment of Ballenger Creek watershed (Roth et al. 2001), we continue to recommend a cautious stormwater management approach in karstic areas. We recommend that Frederick County 1) use the MGS karst susceptibility index as a karst overlay zone, and 2) develop more stringent requirements for new development and redevelopment projects within the overlay zone that will prevent the potentially catastrophic occurrence of new karst features, avoid the enlargement of existing features, and prevent the transmission of surface contaminants and pollution into subsurface waters.

The *2000 Maryland Stormwater Design Manual* (MDE 2000a) states for karst areas, "In general, stormwater runoff should not be concentrated and should be conveyed through vegetated areas…", which is also the goal of an LID approach. Similar recommendations are found in the New Jersey Stormwater BMP Manual, which notes that the New Jersey Geological Survey's recommendations for development in karst areas, presented below, are very similar to those for low impact development (NJDEP 2004).

1. Do not concentrate flows.
2. Minimize grading.
3. Build within landscape (design around existing topography).
4. Do not alter natural drainage areas.
5. Minimize the amount of imperviousness.
6. Increased structural loads at the site can contribute to ground failures.
7. Changes to existing soil profile, including cuts, fills, and excavations, should be minimized.

While the New Jersey Stormwater BMP manual specifically recommends LID approaches for stormwater management in karst areas, it should be noted that there are conflicting recommendations on its use in karst situations. In one example, the US Army Corps of Engineers, Norfolk District (2004) specifically states that LID practices would not be practicable in regions or project sites with high water tables or karst topography. While these contradictions are expected given the complexity and incomplete understanding associated with karstic geology, and the relative newness of LID technologies, Versar believes that LID approaches offer promise for SWM controls, even in karstic areas because of LID's approach to manage small quantities of runoff in a distributed fashion.

3.3 COSTING

We have also included rough cost estimates (i.e., a ±30% range) that may be used for planning purposes. Cost information was gathered from a number of sources that typically included engineering, design, and construction costs. Note that costs may vary depending on location, accessibility, whether or not land or easement purchase is required, and other site-specific factors. Costs for land acquisition or easements were not included in our estimates as we understand the County intends to primarily target projects on land already within County ownership or easements, and Community Restoration Partners would likely work collaboratively with private land owners. The estimates below are intended for general planning purposes only. These general planning costs represent actual costs that in many cases can be off-set or eliminated through the use of existing staff resources, in-kind services, cost-share programs, donated materials, use of volunteers, and other avenues.

In general, cost estimates for the planned LID improvements were based upon two sources: RSMeans Building Construction Cost Data (2005) and RSMeans Environmental Remediation Cost Data – Assemblies (2003). The following describes the general assumptions that were made for these cost estimates.

Construction costs for a linear rain garden were based upon a 1,000 square foot area, 3.5 feet of excavation, and 20 hours of work. Typical rain garden costs were based upon a 500 square foot area, 3.5 feet of excavation, and 10 hours of work. The cost for the construction of a rain garden is extremely variable. Costs for residential rain gardens average about $3 to $4 per square foot, depending on soil conditions and the density and types of plants used. Commercial, industrial, and institutional site costs can range between $10 to $40 per square foot, based on the need for control structures, curbing, storm drains, and underdrains (Coffman et al. 1999). In any rain garden design, the cost of plants varies substantially and can account for a significant portion of the facility's expenditures (Coffman et al. 1999). However, landscaping and maintenance costs would be incurred for these spaces in any case. The rain garden design does not include an underdrain system that would tie into the existing storm sewer lines at the sites. The cost of an underdrain system can range from $10,000 to $50,000 (RSMeans 2005, RSMeans 2003) depending upon size and the length of piping necessary to reach the storm sewer line.

The cost of the infiltration trench is based upon the linear footage of the trench. It was assumed that the trench would be 5 feet in depth. Grass filter strip costs were also based upon the linear footage of the strip and were assumed to be 10 feet wide. Costs for an off-line bioretention facility are anticipated to be similar to those for a dry stormwater management pond, and are based upon a 4.5 foot deep excavation, 1,000 square feet of area, and 40 hours of labor. The design also included the cost of a low flow outlet riser.

Cost estimates for retrofitting existing stormwater management ponds vary widely depending on the nature of the designed improvements. Typically, improvements are necessary to the control structure and outlets to reduce discharge rates, as well as introduction of features to improve water quality. These design and modification costs vary widely and are dependent upon site specific factors.

Because many LID approaches are designed to be integrated into a site design and typically have a multiple-use aspect, implementation costs may be reduced or off-set by existing facility maintenance or improvement programs. For example, landscaping is an on-going expense at many public and private facilities, and this spending typically includes mulching, weeding, seasonal replacement of stressed or annual plantings, pruning, and lawn mowing. Maintenance of bioretention areas and other LID practices have the same requirements, so LID maintenance is not necessarily a new expense for the facility. In addition, introducing LID techniques during normal maintenance/upgrade cycles will reduce both LID implementation costs and regular maintenance spending by sharing expenses between programs.

Costs for stream restoration and riparian buffer projects are based on "Guidelines for Developing Cost Ranges of a Natural Stream Channel Design Project" recently reported by the Keystone Stream Team (2005) for projects in Pennsylvania. These Guidelines provide up-to-date cost range examples, in settings similar to Frederick County, for four identified funding phases appropriate for a natural stream channel design project, namely:

- **Problem Characterization**, including activities such as collection of historical data, location of USGS stream gages, stream walks, documentation of current conditions, agency coordination, and other preliminary steps

- **Development of a Restoration Plan**, including catchment analysis, assessment of available regional curves and stream gage data, development of a regional curve (not required if already exists), field data collection, and analysis of field data to inform the restoration plan

- **Design and Permitting**, including Conceptual Design Phase (field meeting, detailed field surveys, mapping, identification and survey of reference reach, and completion of conceptual design plan); Fluvial Process Verification (collection and analysis of sediment transport data); and Final Design Phase (develop design drawing package, HEC-RAS and other modeling, narrative reports, erosion and sediment control plan, prepare and submit permit applications, and develop project construction cost estimates)

- **Construction and Monitoring**, including both Construction (construction contracting assistance, construction oversight, mobilization/demobilization of equipment, excavation, erosion and sedimentation controls, clearing vegetation, construction materials, in-stream water management, in-stream structures, site stabilization, planting of riparian buffer, and installation of monumented cross sections); and Post-construction Monitoring

Additional details on cost components are provided in Keystone Stream Team (2005). This framework was customized to meet the needs of the present project. Only costs for a limited number of steps were included for riparian buffer restoration and enhancement sites; a more extensive suite of steps were included for stream restoration project sites.

Some costs (e.g., development of a regional curve, broadscale catchment characterization) may be undertaken only once for a group of sites if all are located in the same watershed with similar land uses and physical geography. However, if a group is broken into separate projects that are completed several years apart, some measures may have to be repeated if significant changes in land use have occurred in the intervening time period. Post-construction monitoring costs may vary, depending on whether undertaken by appropriately trained consultant, agency, non-profit, or volunteer personnel.

Versar analysts employed the Keystone Stream Team guideline cost range examples, broke them down into costs per unit, and applied the unit costs to the Ballenger Creek stream restoration sites and riparian buffer restoration and enhancement sites. In most cases, mean total costs are presented for stream restoration projects. An estimated cost range is presented for several of the stream restoration sites because specific stressors and their affect on site conditions have not yet been quantified, introducing a level of uncertainty greater than ± 30 percent; collection of additional data on site condition and stressors will enable more refined cost estimates during future planning stages. These cost estimates do not include:

- Natural diversity surveys
- Act 106 archaeological surveys
- Land development plans
- Zoning variances or waivers
- Changing FEMA maps
- Wetland mitigation

The estimated cost ranges for the 10 identified stream restoration project sites are fairly large. These sites will need considerable study to gather data necessary for engineering design and will require permits prior to construction. Until engineering studies are completed, it is only possible to determine the extent of stream channel re-construction in approximate terms. For example, a stream restoration site may need channel relocation in addition to bank and bed stabilization and riparian buffer planting; the cost for this would be closer to the upper end of the cost range. If the site needed less extensive bank stabilization and riparian buffer enhancement, the cost would be closer to the lower end of the cost range. Significant geomorphologic measurement, in-depth analysis of land cover change, modeling of resulting impacts on flow and sediment transport regimes, and extensive GIS and computer-aided design (CAD) design work are required to determine the magnitude of work required at a particular site.

3.4 UTILITIES

Although underground and overhead utilities may be present at many of the candidate project sites, frequently they are only a minor site constraint that can be worked around by adjusting designs accordingly. We have identified known utilities that were observed at the Tier I sites during field visits and the water and sanitary sewer lines depicted within the County's GIS data (data file: Watersewer83f.shp, 2001). These are noted on the individual project Fact Sheets in Section 4.1.

Once candidate sites have been selected for subsequent feasibility and design phases, a through review of utilities should be undertaken to identify upgrades to known utilities or those not identified in this preliminary review. In addition, prior to any surface disturbance work, a utility locator service should be contacted to mark actual locations.

The following utility contacts are presented to facilitate future utility inquiries (Table 3-1).

Table 3-1. Utility contacts for potential project sites in Ballenger Creek watershed (as of Nov. 2004)

Utility	Contact	Phone
Adelphia Cable	Rick Lushbaugh	301-662-6822 ext. 1200
Alleghany Power	Dirk Junkins Lines Engineering Designer West Of I-270/East Of Rt.15/South Of I-70	301-694-4402
Frederick County Division of Utilities and Solid Waste Management	Dianna Lu	301-631-3509
Verizon	Dennis Schaeffer Engineer 33 East Patrick St. Frederick, MD 21701	301-694-5646
Washington Gas	Orrin Spence	301-644-2377
MISS UTILITY	www.missutility.net	800-257-7777

4.0 SITE-SPECIFIC OPPORTUNITIES

As described in Section 2.5, 74 candidate watershed restoration sites were identified in this study. These sites have been superimposed upon the County's most recent aerial photography from March 2000 and the watershed has been mapped in three sections (West, Central, and East) to provide a readable scale (Figures 4-1, 4-2, and 4-3).

Based on the prioritization process employed in this study, 15 of the Tier 1 candidate sites represent the greatest opportunity for project implementation via the County's CIP, either as individual or grouped projects. We have developed detailed conceptual plans/Fact Sheets in Section 4.1 for these Tier I sites to describe the nature of the problem and recommended approaches for addressing these opportunities. In some cases, we note where implementing action at two or more sites in close proximity would have a beneficial synergistic effect or would follow a logical sequence (e.g., control headwater runoff prior to working on downstream projects). Opportunities at the remaining Tier II sites, as well as the CR sites, have been briefly described in Sections 4.2 and 4.3 should the chance to initiate additional opportunities arise. Although the rankings for these sites are based on a number of important factors, we anticipate that the County will ultimately choose a suite of final sites based on integrating these results with other information, including data not currently available. In addition, some of these projects may be implemented by other organizations.

A review of the County's stormwater management facility database indicates that, within the watershed, as-built plans for 113 facilities are on file with the County as of January 2005. Only one of these facilities, Structure No. 2 – Clearview Detention Pond, is maintained by Frederick County (Division of Parks and Recreation). This facility is included in Tier II as Site 3-9. SWM retrofits were recommended at several private facilities that either control runoff from County facilities or whose discharge may adversely affect County land or infrastructure.

It should also be noted that substantial opportunities to provide additional SWM controls and improve stream stability identified in this study are located on property not owned by the County. In particular, improvement of several sites in the upper portions of King Branch could provide needed flow and water quality controls in a heavily-developed and older neighborhood. These Community Restoration sites represent a wide range of activities, from enhancing streamside buffers to implementation of neighborhood LID projects, and would benefit from some form of County support to facilitate their implementation.

4.1 TIER I CANDIDATE SITES

The following pages present a description of each of the 15 Tier I sites, described in numerical order, by site number. These sites present the best opportunities for the County to implement via its CIP. The maps presented on these project fact sheets indicate potential locations for various project elements at each site. Approximate drainage areas and stream lengths are also reported.

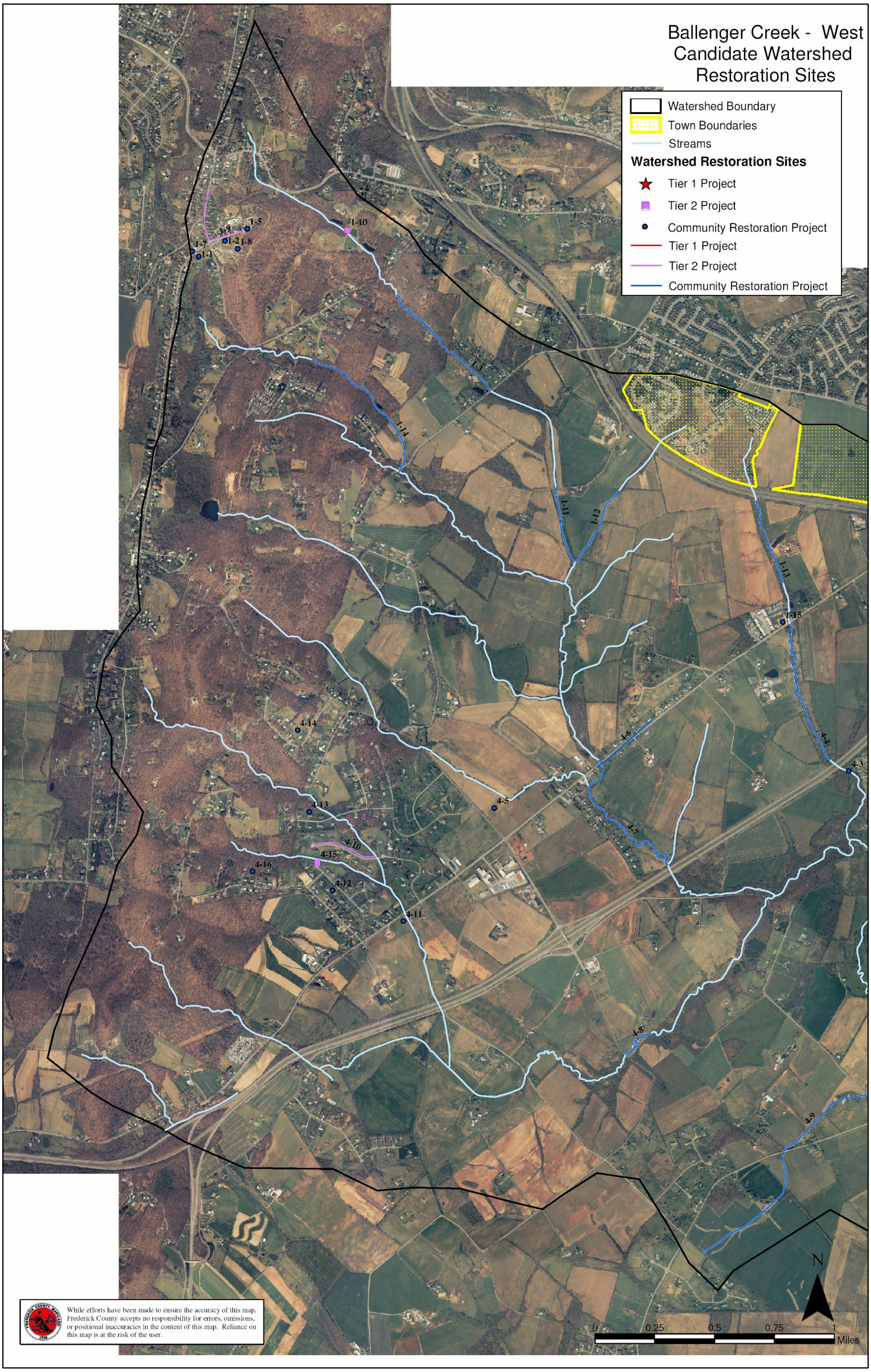


Figure 4-1. Candidate watershed restoration sites identified in Western Ballenger Creek Watershed, Frederick County, MD

Figure 4-2. Candidate watershed restoration sites identified in Central Ballenger Creek Watershed, Frederick County, MD

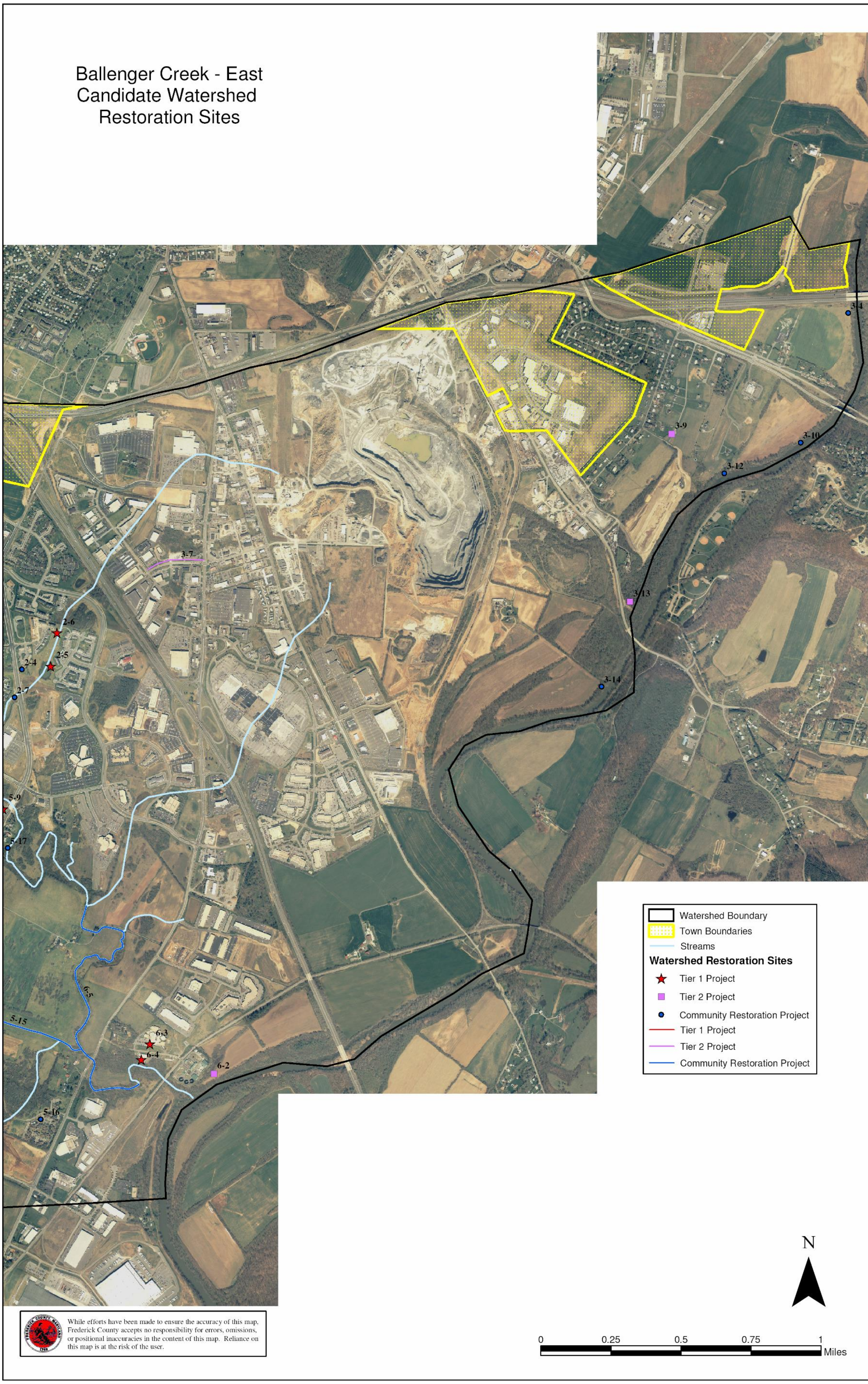
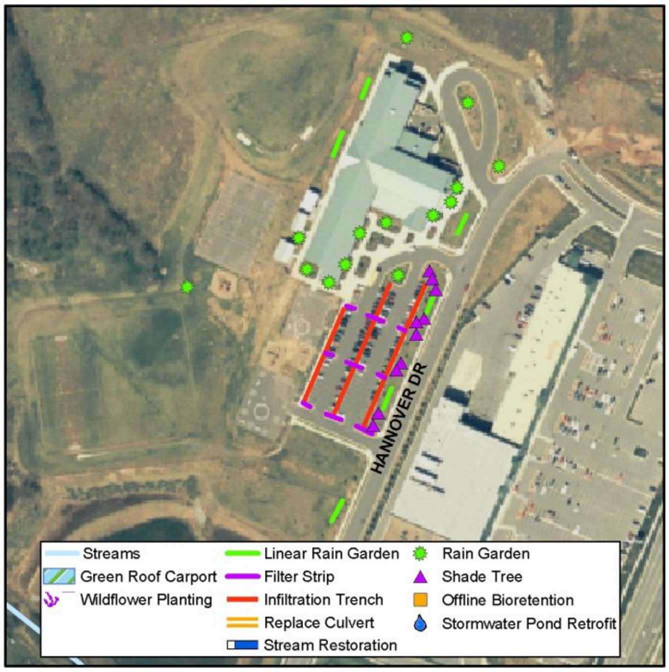


Figure 4-3. Candidate watershed restoration sites identified in Eastern Ballenger Creek Watershed, Frederick County, MD

Site No.:	2-1	**Site Score:**	44
Location:	Orchard Grove Elementary School		
Project Type:	Low Impact Development		
Ownership:	Frederick County Board of Education	**Drainage Area:**	11 acres

Site Description: This site is the Orchard Grove Elementary School. It is situated on a 15.7 acre campus with an estimated impervious area of 1.8 acres. The site is nearly 100 percent clear of all natural vegetation. Impervious surfaces consist of parking lots, sidewalks, and roofs. The site drains to an existing wet pond.

Site Map:



Photograph(s):

Proposed areas for planting bed rain gardens

Proposed area for rain garden near stormdrain inlet

Proposed location for rain garden

Proposed Action: Incorporation of linear rain gardens along Hannover Drive to collect runoff from the roadway. Create grass filter strips draining to infiltration trenches and rain gardens in parking lot islands/borders. Convert planting beds around building foundation into rain gardens to receive redirected roof drainage from disconnected external downspouts. Install two rain gardens in lawn areas to capture runoff before entering stormdrain inlets. Increase buffer/greenway between residential community and school grounds. Include shade trees in parking areas.

Benefit: Pollutant loads, water volume, and water velocity will be reduced from rain gardens along the roadway. Construction and maintenance of rain gardens will serve as educational tools addressing pollution, conservation and stormwater. Parking lot retrofits will reduce loads to existing stormwater drainage system, thereby benefiting the nearby stream and providing additional capacity in the

Site No.: 2-1 (continued)

existing wet pond. Expanding the buffer/greenway and adding shade trees in parking lots will decrease heat island effect, decrease the temperature of water entering nearby surface waters, increase water transpiration, and buffer noise emanating from school grounds.

Proposed location for linear rain garden along road

Planning Level Cost Estimate:

Linear rain gardens	$68,000
Typical rain gardens	$80,000
Infiltration trenches with filter strips	$26,000
Shade trees	$3,000
Buffer/greenway	$13,000
Total:	*$190,000*

Key Issues for Implementation:

Project Sequencing: Implementation may be performed at any time.

Known Utilities & Other Constraints: Water and sanitary sewer, as well as other utilities are nearby. Specific utility locations need to be determined.

Other: Coordinate with school on construction schedule and school sessions. Implementation of rain gardens and buffers during the school year would present a substantial educational opportunity for science classes and the community; parking lot retrofits could be deferred until summer to prevent traffic congestion.

Site No.:	2-2	**Site Score:**	57
Location:	Ballenger Creek Middle School		
Project Type:	Low Impact Development		
Ownership:	Frederick County Board of Education	**Drainage Area:**	26 acres

Site Description: This site is the Ballenger Creek Middle School, built in 1991. It is situated on a 25 acre campus with an estimated impervious area of 3 acres. The site is nearly 100 percent clear of all natural vegetation. Impervious surfaces consist of parking lots, sidewalks and roofs. The site drains via stormwater sewers to a natural stream.

Site Map:

Photograph(s):

Proposed location of linear rain gardens

Proposed area for island rain gardens

Proposed area for island rain gardens

Proposed Action: Incorporation of linear rain gardens along the shoulder of Ballenger Creek Pike to collect runoff from roadway. Create grass filter strips draining to an infiltration trench and rain gardens in parking lot islands/borders. Divert roof drainage to rain gardens behind school. Reduction of overall non-used field areas by conversion to tree stands/greenways.

Benefit: Pollutant loads, water volume, and water velocity will be reduced from rain gardens along roadway. Construction and maintenance of rain gardens will provide a major educational benefit to address pollution, conservation and stormwater issues. Infiltration trenches and grass filter strips in parking areas will reduce loads to existing stormwater drainage system thereby benefiting the nearby stream. Runoff from roofs will infiltrate via rain gardens. Reduction of unused fields will decrease heat island effect,

Site No.: 2-2 (continued)

decrease water temperature entering nearby surface waters, improve wildlife habitat, and increase water transpiration.

Proposed location for infiltration trench between parking rows

Planning Level Cost Estimate:

Linear rain gardens	$34,000
Typical rain gardens	$40,000
Infiltration trenches with filter strips	$11,000
Tree stands/greenways	$7,000
Total:	*$92,000*

Key Issues for Implementation:

Project Sequencing: Implementation may be performed at any time.

Known Utilities & Other Constraints: Sanitary sewer line located at site. Water lines, as well as other utilities are nearby. Specific utility locations need to be determined.

Other: Coordinate with school on construction schedule and school sessions. Implementation of rain gardens and tree plantings during the school year would present a substantial educational opportunity for science classes and the community; parking lot retrofits could be deferred until summer to prevent traffic congestion.

Site No.: 2-5 **Site Score:** 46

Location: Arundel Branch at Frederick Village Subdivision

Project Type: Riparian Woodland and Meadow Buffer

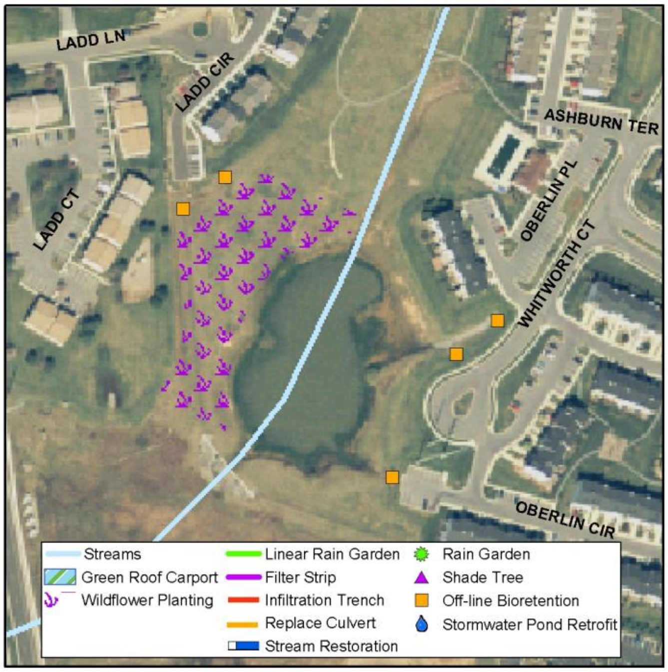
Ownership: Land dedicated to Frederick County

Stream Length: 3,300 linear feet

Drainage Area: 15 acres

Site Description: Arundel Branch has been dammed with a weir to form a wet pond, wetland, and short stream channel. Several stormwater outfalls drain to the corridor. There is no riparian buffer.

Site Map:



Photograph(s):

Wetland and stream without buffer

Pond without buffer

Proposed Action: Plant 50-foot wide riparian woodland buffer around pond and along streams. Plant wildflower meadows between buffer and crest of slope below homes, leaving existing walking paths and their connections to adjacent communities. Build off-line bioretention cells at end of five stormwater pipe outfalls.

Benefit: Promote infiltration and provide passive recreation opportunities in development.

Planning Level Cost Estimate:

Off-line bioretention	$83,000
Buffer	$86,000
Wildflower plantings	$2,000
Total:	*$171,000*

Site No.: 2-5 (continued)

Key Issues for Implementation:

Project Sequencing: Initiate in conjunction with 2-6.

Known Utilities & Other Constraints: Sanitary sewer and water lines located at or near several project element locations. Other utilities are nearby. Specific utility locations need to be determined.

Other: Subsurface testing and other special precautions may be necessary during design and implementation phases because this site is located in a karst-prone area.

Site No.: 2-6 **Site Score:** 46

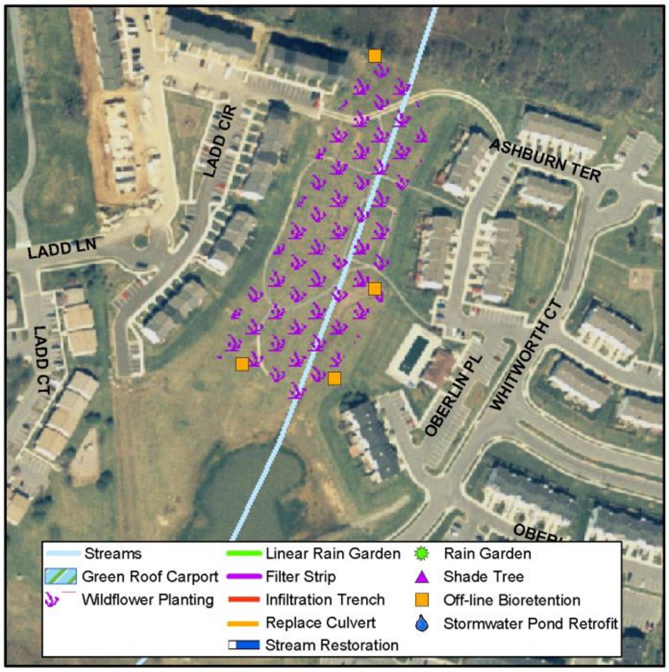
Location: Arundel Branch at Foxcroft II Subdivision

Project Type: Riparian Woodland and Meadow Buffer

Ownership: Land dedicated to Frederick County **Drainage Area:** 16 acres

Site Description: Four stormwater outfalls drain to an open space corridor along Arundel Branch, above a wet pond (Site 2-5). There is no riparian buffer.

Site Map:



Photograph(s):

Stormdrain outfall and walking path

Proposed Action: Plant wildflower meadows between buffer and crest of slope below homes, leaving existing walking paths and their connections to adjacent communities. Build off-line bioretention cells at four stormwater outfalls.

Benefit: Promote infiltration and provide benches and other passive recreation opportunities.

Planning Level Cost Estimate:

Off-line bioretention	$66,000
Wildflower plantings	$3,000
Total:	*$69,000*

Key Issues for Implementation:

Project Sequencing: Initiate in conjunction with 2-5.

Known Utilities & Other Constraints: Sanitary sewer and water lines located at or near several project element locations. Other utilities are likely. Specific utility locations need to be determined.

Other: Subsurface testing and other special precautions may be necessary during design and implementation phases because this site is located in a karst-prone area.

Site No.:	2-11	**Site Score:**	64
Location:	Pike Branch behind Ballenger Creek Middle School		
Project Type:	Stream Restoration and Stormwater Retrofit		
Ownership:	Open space dedicated to Frederick County (some areas within Farmbrook subdivision are specifically dedicated for stormwater management and parkland) and PEPCO utility easement	**Stream Length:** **Drainage Area:**	3,000 linear feet 107 acres

Site Description: Construction of stormwater control wetland for development has interrupted natural hydrology of adjacent Pike Branch, severely reducing base flow in stream channel. Berm has been built between wetland and stream channel. Weir for the wet pond is weathered and in disrepair. Ponding in wetland below the weir and in the stream periodically inundates the sewer line manholes. Riparian buffer consists largely of invasive species.

Site Map:

Photograph(s):

Stormwater wetland parallel to Pike Branch

Proposed Action: Establish connections through the berm between the wetland and the natural stream to restore the stream's natural flow regime. Construct off-line bioretention cells at end of 13 stormwater pipe outfalls along concrete-lined ditches in adjacent Farmbrook development. Retrofit existing stormwater pond to reduce weir capacity no longer needed because of pipe outfall retrofits. Remove invasive species and plant riparian buffer with native species. Build walking/biking path on berm with connecting path and bridge to school and development.

Pike Branch: reduced base flow and invasive species

Site No.: 2-11 (continued)

Benefit: Improved habitat and water quality via restoration of more natural stream hydrology and off-line bioretention capture of stormwater runoff. Remove stormwater infiltration potential in sanitary sewer. Excellent recreational and educational opportunity due to proximity to Ballenger Creek Middle School.

Flooded woodland and sewer line

Planning Level Cost Estimate:

Off-line bioretention	$215,000
SWM pond retrofit	$2,000
Stream restoration and buffer	$616,000
Total:	*$833,000*

Key Issues for Implementation:

Project Sequencing: Initiate after Site 2-2 at Ballenger Creek Middle School. Wetland-stream connections and native riparian plantings should take place and be analyzed for effectiveness before weir capacity is adjusted.

Concrete-lined Pike Branch

Known Utilities & Other Constraints: Sanitary sewer and water lines located at or near several project element locations. Other utilities are likely. Specific utility locations need to be determined.

Other: Presence of man-made wetlands may complicate permitting. A portion of the proposed project is located on land dedicated, but not deeded to the County, and within a utility easement and would require coordination with the Farmbrook HOA and PEPCO.

Proposed location for off-line bioretention

Site No.: 4-1 **Site Score:** 54

Location: Ballenger Creek Park

Project Type: Low Impact Development

Ownership: Frederick County Div. of Parks & Recreation **Drainage Area:** 77 acres

Site Description: Ballenger Creek Park is situated on 57.7 acres. The site is almost 100 percent clear of all natural vegetation. Impervious surfaces consist of parking lots, sidewalks, roadways and some roofs. The site drains directly to Ballenger Creek. The park contains extensive mowed lawn areas.

Site Map:

Photograph(s):

Proposed location for rain garden near outlet of stormwater pipe

Proposed location for linear rain garden

Proposed location for infiltration trench and traffic island rain gardens

Proposed Action: Incorporation of linear rain gardens along entrance road. Create rain gardens and filter strips in northern parking lot islands/borders and rain gardens and infiltration trench in southern parking lot. Create rain garden at outfall below baseball fields. Reduce overall non-used lawn areas by conversion to tree stands/greenways.

Benefit: Pollutant loads, water volume, and water velocity will be reduced from rain gardens along roadway. Construction and maintenance of rain gardens will serve as educational tools addressing pollution, conservation and stormwater. Parking lot rain gardens and infiltration trenches will reduce stormwater reaching the nearby stream. Reduction of unused fields and mowed areas will decrease heat island

Site No.: 4-1 (continued)

effect, decrease water temperature entering nearby surface water, and increase water transpiration. Reduction in mowed areas will also reduce maintenance costs and improve quality of wildlife habitat.

Planning Level Cost Estimate:

Linear rain gardens	$90,000
Typical rain gardens	$29,000
Infiltration trenches with filter strips	$12,000
Tree stands/greenways	$13,000
Total:	*$144,000*

Key Issues for Implementation:

Project Sequencing: May be initiated at any time.

Known Utilities & Other Constraints: Water lines located at or near the outfall below the baseball field. Other utilities are likely. Specific utility locations need to be determined.

Other: None identified.

Site No.:	5-1	**Site Score:**	53
Location:	Ballenger Creek Elementary School		
Project Type:	Low Impact Development		
Ownership:	Frederick County Board of Education	**Drainage Area:**	9 acres

Site Description: The Ballenger Creek Elementary School is situated on an approximately 20-acre campus with an estimated impervious area of 7 acres. The site is nearly 100 percent clear of all natural vegetation. The impervious surfaces consist of parking lots, sidewalks and roofs. The site does not have SWM controls; areas along Kingsbrook Drive drain via storm drains to King Branch, while most of the site drains directly to Ballenger Creek, located behind the school (Site 5-2).

Site Map:

Photograph(s):

Proposed location for linear rain gardens

Proposed location for island rain gardens

Proposed location for rain garden

Proposed Action: Incorporation of linear rain gardens between sidewalks and Kingsbrook Drive to collect runoff from roadway and eastern side of parking lot. Create rain gardens and infiltration trenches in parking lot islands/borders. Create rain gardens in planting beds in front of school and near asphalt play areas behind the school. Increase buffer/greenway between residential community and school grounds

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Site No.: 5-1 (continued)

Benefit: Introduction of rain gardens and other LID techniques will reduce pollutant loads, water volume, and water velocity stemming from the school property. Construction and maintenance of rain gardens will serve as community and classroom educational tools addressing pollution, conservation and stormwater. Linear rain gardens along Kingsbrook Drive will reduce loads to existing storm drain system thereby benefiting nearby King Branch. Parking lot rain gardens will provide flow quantity and quality controls to protect Ballenger Creek. Increasing buffer/greenway around property margins and along the mainstem will decrease heat island effect, decrease water temperature entering nearby surface waters, improve wildlife habitat, and increase water transpiration.

Planning Level Cost Estimate:

Linear rain gardens	$23,000
Typical rain gardens	$34,000
Infiltration trenches	$24,000
Buffer/greenways	$26,000
Total:	*$107,000*

Key Issues for Implementation:

Project Sequencing: Implementation should be performed in conjunction with Site 5-2.

Known Utilities & Other Constraints: Sanitary sewer and water lines located at or near several project element locations. Other utilities are likely. Specific utility locations need to be determined.

Other: Coordinate with school on construction schedule and school sessions. Implementation of rain gardens and tree plantings during the school year would present a substantial educational opportunity for science classes; parking lot retrofits could be deferred until summer to prevent traffic congestion.

Site No.:	5-2	**Site Score:**	60
Location:	Ballenger Creek Elementary School – Reach 1		
Project Type:	Stream Restoration and Riparian Buffer Enhancement		
Ownership:	Frederick County Board of Education	**Stream Length:**	600 linear feet

Site Description: Stream reach immediately behind Ballenger Creek Elementary School and next to proposed Ballenger Creek Trail. Stream channel is entrenched with overly wide channel, eroded banks, inadequate riparian buffer, and silt deposits on streambed. Outdoor education classroom present but in need of repair.

Site Map:

Photograph(s):

Eroded banks and narrow buffer

Proposed Action: Natural stream channel design restoration and riparian buffer enhancement. Restore outdoor classroom utility.

Benefit: Improved habitat and water quality. Excellent educational opportunity due to proximity to Ballenger Creek Elementary School and Ballenger Creek Trail.

Planning Level Cost Estimate: $160,000 - $420,000 (design, construction, and planting; assumes no channel relocation)

Key Issues for Implementation:

Project Sequencing: Initiate in conjunction with SWM retrofits at School (5-1). Stream restoration activities at 5-10 and 5-5 should follow this site.

Site No.: 5-2 (continued)

Known Utilities & Other Constraints: Sanitary sewer line runs along the eastern stream bank, crosses the channel at the bottom of this restoration reach, and runs to the school. Water lines, as well as other utilities are likely. Specific utility locations need to be determined.

Other: Coordinate with school on construction schedule and school sessions as it may be desirable to conduct work during the summer when school is not in session. Implementation would present a substantial educational opportunity for science classes and the community.

Site No.: 5-5 **Site Score:** 68

Location: Mainstem Ballenger Creek near proposed Trail Loop and parking area, New Design Road

Project Type: Stream Restoration, Buffer Enhancement

Ownership: Land dedicated to Frederick County **Stream Length:** 1,500 linear feet

Site Description: Stream reach next to proposed Ballenger Creek Trail and proposed Trail loop and parking lot. Stream channel is extremely unstable, has eroded banks and inadequate forested buffer, and has developed several high flow meander cutoffs, massive woody debris jams, and silt deposits. There is a high potential for the channel to adjust its path laterally as a result of these instabilities, thereby threatening the proposed Trail and parking areas. Uncontrolled site drainage from Robin Meadows Subdivision (Site 5-12) enters Ballenger Creek immediately above this site.

Site Map:

Photograph(s):

Undercut trees

Cutoff and debris jam

Proposed Action: Natural stream channel design restoration of channel geometry and riparian buffer enhancement.

Benefit: Stream restoration would remove the threat of imminent lateral stream channel adjustments into the Ballenger Creek Trail by reestablishing equilibrium between channel capacity and flow regime. It would also stabilize channel location so as not to adversely effect the Ballenger Creek Trail construction or downstream infrastructure, remove public safety hazards that will become more accessible with Trail use, and also serve as a significant amenity to attract visitors to the Trail.

Site No.: 5-5 (continued)

Stream restoration and riparian enhancement would improve habitat function by reconnecting the 2-year flow to the floodplain, improve water turbidity, remove invasive species, buffer the stream from adverse impacts from Trail use and parking.

This project, in conjunction with improvements on other reaches, may provide the County with a Waterway/Greenway opportunity to enhance the Trail Project, providing enhanced recreational and educational utility, and may also be used to leverage additional funding.

Undercut trees

Planning Level Cost Estimate: $260,000 - $630,000 (design, construction, and planting; assumes no channel relocation)

Key Issues for Implementation:

Project Sequencing: Implementation should follow upstream restoration at Sites 5-2 and 5-12. Complete design in conjunction with upstream Site 5-10, and before designing or constructing nearby Trail section (Site 2-7) to avoid site conflict and future damage to Trail from lateral channel erosion.

Known Utilities & Other Constraints: Overhead electric transmission line crosses stream above impacted reach; overhead electric distribution lines cross impacted stream reach. Sanitary sewer lines cross the stream in three locations, and parallel the north side of the stream. Water lines and other utilities may be located likely. Specific utility locations need to be determined.

Other: Implementation would present a substantial educational opportunity for Trail users and the community. Subsurface testing and other special precautions may be necessary during design and implementation phases because this site is located in a karst-prone area.

Site No.:	5-7	**Site Score:**	53
Location:	Ballenger Cr. Trail - loop and parking area at New Design Road		
Project Type:	Low Impact Development		
Ownership:	Frederick County	**Drainage Area:**	24 acres

Site Description: This site is currently an open field that is a proposed parking lot for a one-mile trail loop for the Ballenger Creek Trail project. It is bounded on the north by Ballenger Creek (Site 5-5) and on the south by a residential community. The site is 90 percent actively farmed as row crops; the remaining 10 percent contains trees.

Site Map:

Photograph(s):

County-proposed location for Ballenger Creek Trail parking and loop-trail

Proposed location for off-line bioretention area at stormwater pipe outfall

Proposed Action: Plans for development of this site should incorporate LID techniques to capture and treat stormwater runoff via infiltration and plant uptake. Elements for consideration should include construction of tree-box rain gardens at the edges of parking areas, linear rain gardens placed along sidewalks, limiting the amount of paving and other impervious areas, and avoiding, where possible, the compaction and disturbance of existing soils. Off-line bioretention cells should be developed for the three existing discharges from the adjacent residential community. All existing trees should be preserved in place. In addition, open space areas disturbed during construction should be depressed slightly (e.g., 1 inch), with enhancement of the soil to facilitate depression storage and infiltration.

Site No.: 5-7 (continued)

Benefit: Pollutant loads, water volume, and water velocity would be reduced by the tree-box and other rain garden elements for the parking lot and sidewalks. The off-line bioretention cells will trap pollutants and reduce stormwater loads to Ballenger Creek. The rain gardens and preservation of existing trees will attract wildlife to the area and improve site aesthetics. Depression of all open space will facilitate infiltration (but not result in long-term standing water). Minimizing soil compaction will retain the natural storage and infiltration capacity of the site soils. Substantial educational benefits are associated with using innovative stormwater controls at the site.

Planning Level Cost Estimate:	Off-line bioretention	$50,000
	Depression of open space	$63,000
	Total:	*$113,000*

Key Issues for Implementation:

Project Sequencing: Stream stability issues at Site 5-5 should be addressed prior to site development to prevent channel adjustments from damaging trail or parking areas. Also, plan in conjunction with nearby site 5-7.

Known Utilities & Other Constraints: Overhead electric distribution line crosses the site but is not likely to pose problems. Sanitary sewer lines are located at the site near the development and water lines run next to New Design Road. Other utilities are likely. Specific utility locations need to be determined.

Other: Implementation would present a substantial educational opportunity for Trail users and the community. Subsurface testing and other special precautions may be necessary during design and implementation phases because this site is located in a karst-prone area. Costs included in this estimate include three off-line bioretention cells and depression of open spaces by 1-inch; other LID elements recommended for incorporation into the Trail designs are not included.

Site No.:	5-9	**Site Score:**	44
Location:	Ballenger Creek Trail above New Design Road		
Project Type:	Low Impact Development		
Ownership:	Frederick County	**Drainage Area:**	8 acres

Site Description: This site is currently an open field proposed for development as part of the Ballenger Creek Trail. It is bounded on the north by Ballenger Creek and on the southwest by a residential community. On the east, the site drains New Design Road. The site is 90 percent clear of all native vegetation; the remaining 10 percent contains trees.

Site Map:

Photograph(s):

Proposed location for off-line bioretention cell and linear rain gardens

Proposed Action: Construct linear rain gardens along New Design Road and divert road drainage to these facilities. Construct an off-line bioretention cell at the stormwater pipe outfall near the bridge for New Design Road. Existing trees should be preserved in place and the riparian buffer along the stream should be increased. In addition, open space areas should be depressed slightly (e.g., 1 inch), with enhancement of the soil to facilitate depression storage and infiltration.

Benefit: Pollutant loads, water volume, and water velocity will be reduced. The off-line bioretention and linear rain gardens will trap pollutants and reduce stormwater loads to Ballenger Creek. The rain gardens will improve wildlife habitat. Depression of all open space will facilitate infiltration (but not result in long-term standing water).

Planning Level Cost Estimate:

Linear rain gardens	$45,000
Off-line bioretention	$17,000
Depression of open space	$29,000
Buffer/greenways	$18,000
Total:	*$109,000*

Site No.: 5-9 (continued)

Key Issues for Implementation:

Project Sequencing: Plan in conjunction with nearby sites at 5-5 and 5-7.

Known Utilities & Other Constraints: Overhead electric distribution line crosses the site but is not likely to pose problems. Sanitary sewer lines are located at the site. Water and other utilities are likely. Specific utility locations need to be determined.

Other: Subsurface testing and other special precautions may be necessary during design and implementation phases because this site is located in a karst-prone area.

Site No.:	5-10	**Site Score:**	60
Location:	Ballenger Creek Elementary School – Reach 2		
Project Type:	Stream Restoration and Riparian Buffer Enhancement		
Ownership:	Land dedicated to Frederick County	**Stream Length:**	900 linear feet

Site Description: Stream reach southeast of Ballenger Creek Elementary School, immediately downstream from Reach 1 and sewer line crossing. Site is adjacent to proposed Ballenger Creek Trail. Stream channel is entrenched with overly wide channel, eroded banks, trash, debris blockages, inadequate riparian buffer, and silt deposits on streambed.

Site Map:

Photograph(s):


Debris jam and eroded banks

Proposed Action: Natural stream channel design restoration and riparian buffer enhancement. Replace streambank concrete lining at sewer line crossing with boulders to increase roughness, yet maintain protection for sewer line. Remove debris jam and accumulated trash.

Benefit: Improved habitat and water quality. Excellent educational opportunity due to proximity to Ballenger Creek Trail and Ballenger Creek Elementary School.

Planning Level Cost Estimate: $200,000 - $490,000 (design, construction, and planting; assumes no channel relocation)

Key Issues for Implementation:

Project Sequencing: The restoration design should be completed at the same time as Site 5-5 located downstream.

Known Utilities & Other Constraints: Sanitary sewer lines cross the stream in two locations. Water lines and other utilities may be located nearby. Specific utility locations need to be determined.

Site No.: 5-11 (continued)

Other: Implementation would present a substantial educational opportunity for Trail users and the community.

Site No.: 5-12 **Site Score:** 47

Location: Robin Meadows Subdivision

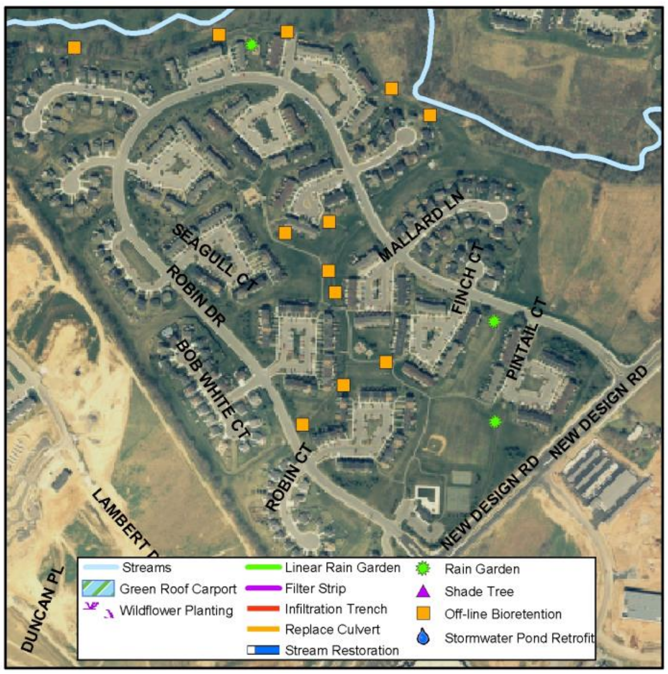
Project Type: Low Impact Development and Streambank Stabilization

Ownership: Frederick County; open space dedicated to Frederick County; and Robin Meadows LTD Partnership/ community open space.

Drainage Area: 89 acres
Stream Length: 25 linear feet

Site Description: Multiple stormwater outfalls drain via mowed lawn or wide, flat, grassed swales, through a narrow riparian buffer to mainstem Ballenger Creek. Some control is provided by a weir located between Kingfisher Court and Mallard Lane. Local impact from stormwater is relatively minor, consisting of minor scour at the weir and bank erosion as flows enter Ballenger Creek; cumulative downstream impact is substantial.

Site Map:



Bank erosion from the stormwater swale as flows enter Ballenger Creek

Minor scour below the stormwater weir near Mallard Lane

Proposed Action: Build off-line bioretention gardens at 12 stormwater pipe outfalls within the subdivision and rain gardens at three other locations. Plant a wildflower meadow throughout the bottom of the wide swales. Stabilize the streambank where the flow from the central swale enters the stream, located near the end of Mallard Lane.

Benefit: Promote runoff infiltration/evapotranspiration and reduce overland flow via rain gardens and off-line bioretention. Prevent continued bank erosion at Ballenger Creek. Wildflower meadow would improve wildlife habitat and aesthetics, and also reduce maintenance mowing costs.

Proposed location for off-line bioretention

Site No.: 5-12 (continued)

Planning Level Cost Estimate:

Typical rain gardens	$17,000
Off-line bioretention	$199,000
Wildflower plantings	$12,000
Streambank stabilization	$12,000
Total:	*$240,000*

Proposed location for rain garden

Key Issues for Implementation:

Project Sequencing: Implementation should take place prior to stream restoration work at Site 5-5.

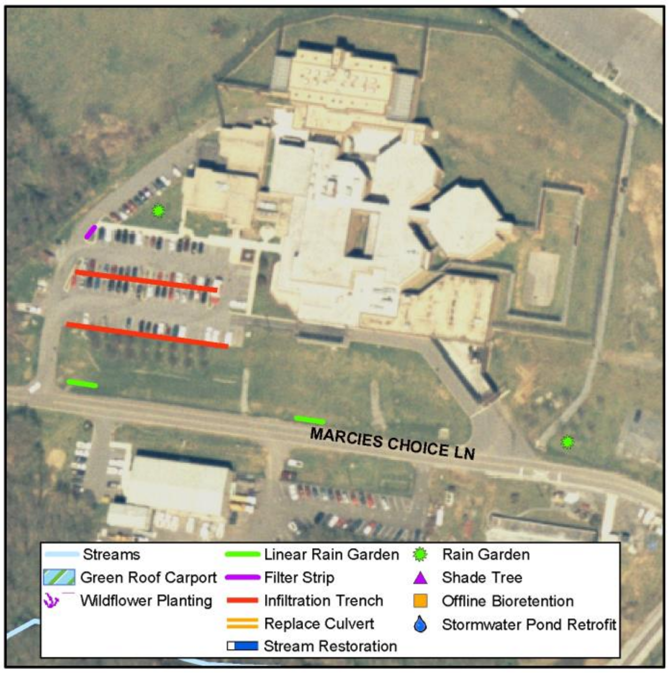
Known Utilities & Other Constraints: Sanitary sewer and water lines are located at or near most project element locations, but are not a substantial constraint. Other utilities are nearby. Specific utility locations need to be determined.

Other: Subsurface testing and other special precautions may be necessary during design and implementation phases because this site is located in a karst-prone area. The affected stream and several stormwater outfalls are located on County property; however, a portion of the proposed project is on private land and would require coordination with the owner.

Site No.:	6-3	**Site Score:**	49
Location:	Frederick County Adult Detention Center		
Project Type:	Low Impact Development		
Ownership:	Frederick County Sheriff's Office - Corrections Bureau	**Drainage Area:**	8 acres

Site Description: The County's adult detention center is nearly 100 percent clear of all natural vegetation, with 70 percent of the site converted to impervious surface. These impervious surfaces include a parking lot, sidewalks, exercise yards, and roofs. The total facility is 16,988 square feet.

Site Map:



Photograph(s):

Entrance to Detention Center with adjacent depression

Existing drainage swales leading under the road

Proposed Action: Depression of all grassed yards to a slight depth (e.g., 1 inch), with enhancement of the soil to facilitate depression storage and infiltration. Create infiltration trenches in parking areas. Development of linear rain gardens along road front in depression near entrance and in existing drainage swales utilizing only plants with minimal height, and an additional rain garden in a traffic island adjacent to the parking areas.

Benefit: Pollutant loads, water volume, and water velocity will be reduced by incorporation of the depressed yards (but not result in long-term standing water). Infiltration trenches and rain gardens will capture road and parking lot runoff, thereby benefiting the surrounding surface water by decreasing pollutants, water volume, and water velocity.

Site No.: 6-3 (continued)

Planning Level Cost Estimate:	Typical rain gardens	$11,000
	Linear rain gardens	$23,000
	Infiltration trenches with filter strip	$17,000
	Depressed yards	$12,000
	Total:	*$63,000*

Key Issues for Implementation:

Project Sequencing: Implementation may be performed at any time.

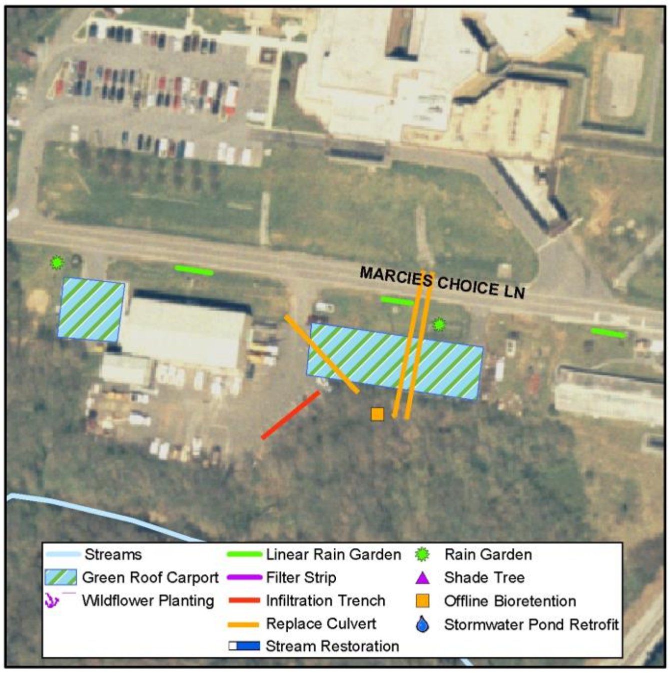
Known Utilities & Other Constraints: Sanitary sewer line located at site. Water lines, as well as other utilities are likely. Specific utility locations need to be determined. Facility is a high security area and close coordination with the Sheriff's Office on security issues is critical.

Other: Maintenance of security and line of sight is key design requirement for LID elements. Subsurface testing and other special precautions may be necessary during design and implementation phases because this site is located in a karst-prone area.

Site No.:	6-4	**Site Score:**	49
Location:	Division of Utilities and Solid Waste Management (DUSWM) Office, Marcie's Choice Lane		
Project Type:	Low Impact Development		
Ownership:	Frederick County DUSWM	**Drainage Area:**	3 acres

Site Description: This site is the office and maintenance yard for DUSWM. Buildings and parking areas comprise approximately 4 acres. The site drains to mainstem Ballenger Creek. Site 6-3, the adult detention center, is located across the street. Drainage from the detention center flows into three culverts beneath Marcie's Choice Lane and the DUSWM parking areas. Road drainage also flows into a SWM facility located on the property. Vertical drop at the outfalls from these pipes is approximately 7 feet, causing major scour immediately below the outfall and down an intermittent channel (approximately 300 feet) to Ballenger Creek.

Site Map:




Proposed location for linear rain garden along


Proposed conversion to rain garden


Proposed location for infiltration trench

Proposed Action: Replace culverts beneath parking lots and retrofit stormwater outfall with an off-line bioretention facility. Repair scour hole and restore intermittent channel. Incorporate linear rain gardens along Marcie's Choice Lane to collect runoff from roadway. Create rain gardens in parking lot islands/borders. Install green roofed carports in parking areas.

Benefit: Pollutant loads, water volume, and water velocity will be reduced from linear rain gardens along the roadway. Rain gardens and off-line bioretention will reduce loads to nearby stream. Channel restoration will prevent future enlargement of eroded channel and reduce bank erosion and sediment load delivered to Ballenger Creek. The green roofed carports will decrease water volume and heat island effect.

Site No.: 6-4 (continued)

Planning Level Cost Estimate:	Typical rain gardens	$11,000
	Linear rain gardens	$34,000
	Off-line bioretention	$17,000
	Repair scour hole and stabilize stream	$10,000
	Culvert repairs	$24,000
	Green roof carports	$117,000
	Total:	*$213,000*

Proposed location for culvert replacements and repair of scour hole

Key Issues for Implementation:

Project Sequencing: Implement controls at Site 6-3 in conjunction with repairs and other measures at this site.

Known Utilities & Other Constraints: Sanitary sewer and water lines located at site. Other utilities are likely. Specific utility locations need to be determined.

Other: Subsurface testing and other special precautions may be necessary during design and implementation phases because this site is located in a karst-prone area.

4.2 TIER II CANDIDATE SITES

The following 14 additional candidate sites represent good opportunities for the County or their partners to implement watershed restoration projects, including improvements to stormwater management (Table 4-1).

Table 4-1. Tier II candidate projects

Site No.	Total Score (max. 100)	Ownership	Proposed Action	Extent of Project (approximate)	Rain Gardens	Linear Rain Gardens	Off-line Bioretention	Infiltration Trench	Tree Planting	SWM Pond Retrofit	Culvert Retrofit	Depression of Open Space	Roadbed Removal	Filterra Stormdrain Inserts	Planning Level Cost Estimate (± 30 percent)
1-9	26	Road ROW	Linear rain gardens along Maryland Avenue to capture runoff from roadway.	6,000 sq. ft.		$68,000									$68,000
1-10	38	Private/Road ROW	Two rain gardens to capture road runoff from Running Spring Court. Linear rain garden along Running Spring Court.	9,000 sq. ft.	$11,000	$90,000									$101,000
2-14	41	Dedicated to County	Retrofit culvert at Corporate Drive and King Branch to provide extended detention	1,500 sq. ft.							$4,000				$4,000
2-19	36	Dedicated to County	Retrofit culverts at Corporate Drive and Arundel Branch to provide extended detention	1,500 sq. ft.							$4,000				$4,000
3-7	26	Road ROW	Rain garden swales and bioretention along Grove Road.	7,000 sq. ft.	$11,000	$68,000									$79,000
3-9	38	Div. Parks and Recreation	Retrofit existing stormwater pond to facilitate infiltration of rainwater to groundwater by lengthening flow path and adding multi-cell micro-rain gardens. The remaining pond should have the existing grass cover converted to native meadow vegetation.	15,000 sq. ft.						$100,000					$100,000
3-13	41	Road ROW	Convert abandoned Reichs Ford roadbed at the Monocacy River to a bioretention cell to receive runoff flowing down (both sides of) the road towards the river. Revegetate bioretention area and roadbed with trees to fill remaining gap in forest cover.	6,500 sq. ft.			$17,000		$12,000				$22,000		$51,000
4-2	39	Board of Education	Tuscarora High School LID retrofits – create rain gardens in parking lot islands/borders and in planting beds around the school foundation. Replace storm drain inlets with manufactured bioretention inserts. Reduction of overall non-used field areas by conversion to tree stands/greenways.	0.65 acres/ 290 lf	$74,000			$12,000	$13,000						$99,000
4-10	41	Road ROW	Rain garden swales and infiltration trench along Wye Creek Dr.	8,000 sq. ft./ 490 lf		$90,000		$26,000							$116,000
4-15	39	Road ROW	Install rain garden in cul-de-sac on Woodhirst Drive	500 sq. ft.	$6,000										$6,000
5-8	39	Board of Education	Tuscarora Elementary School LID retrofits – create rain gardens in parking lot islands/borders and in planting beds around the school foundation. Replace storm drain inlets with manufactured bioretention inserts. Reduction of overall non-used field areas by conversion to tree stands/greenways.	1.4 acres/ 290 lf	$74,000			$12,000	$38,000						$124,000
5-11	38	Road ROW	Kingsbrook Drive Filterra® units near Ballenger Creek Elem. School	144 sq. ft.										$30,000	$30,000
5-14	16	Road ROW	Rain gardens (3) before storm sewer inlet for old segment of English Muffin Way; remove old roadbed to reduce imperviousness	10,000 sq. ft.	$17,000								$30,000		$47,000
6-2	27	DUSWM	Perimeter rain gardens around Ballenger Creek wastewater treatment plant. Depression of grassed areas for infiltration.	19,500 sq. ft.	$29,000	$23,000						$12,000			$64,000

4.3 COMMUNITY RESTORATION SITES

The following 45 candidate sites represent opportunities for watershed restoration via the County's Community Restoration partners (Table 4-2). At a number of sites, the opportunity and need for improvements are similar to the Tier I sites, however, these sites are not likely to be eligible for implementation under the County's CIP. Most of these sites are located on private land and would require further coordination with local property owners.

Table 4-2. List of identified Community Restoration sites

Site No.	Total Score (max. 100)	Land Use	Proposed Action	Extent of Project (approximate)	Rain Gardens	Linear Rain Gardens	Off-line Bioretention	Berm	Plantings	SWM Pond Retrofit	Culvert Retrofit	Rain Barrels	Maintenance	Stream Restoration	Planning Level Cost Estimate (± 30 percent)
1-1	29	Urban	Reduce lawn area behind fire station by converting grassed area to meadow. Rain gardens in NW & NE corners of lot near roadway. Clean-out infiltration basin.	16,000 sq. ft.	$11,000				$9,000				$1,000		$21,000
1-2	40	Urban	Retrofit SWM pond. Depress flag pole area and plant as rain garden. Expand downspout flower beds, plant as rain garden. Rain garden at NW & NE corners of parking lot.	16,500 sq. ft.	$21,000					$100,000					$121,000
1-3	33	Agricultural	Stream stabilization and plant riparian buffer	4,000 feet										$490,000 - $1,020,000	$490,000 - $1,020,000
1-5	26	Urban	Rain gardens around community center. Berm perimeter of property.	2,500 sq. ft./ 1,000 lf	$29,000			$2,000							$31,000
1-7	22	Urban	Remove trash across from Braddock Heights Fire Co	1 acre									$2,500		$2,500
1-8	22	Urban	Contour slope with berms and replant with native vegetation.	0.8 acres				$5,000							$5,000
1-11	26	Agricultural	Plant riparian buffer	2,000 feet					$56,000						$56,000
1-12	35	Agricultural	Plant riparian buffer	2,000 feet					$56,000						$56,000
1-13	26	Agricultural	Plant riparian buffer	2,000 feet					$56,000						$56,000
1-14	32	Agricultural	Plant riparian buffer	4,000 feet					$101,000						$101,000
1-15	41	Urban	Rain Garden swales along Jefferson Pike and stream crossing.	6,000 sq. ft.		$68,000									$68,000
2-3	57	Urban	Off-line bioretention cells at four stormwater pipe outfalls. Culvert retrofit at Arbor Drive road crossing. Plant wildflower meadow throughout the wide swale.	2 acres			$66,000		$2,000		$4,000				$72,000
2-4	39	Urban	Remove invasive species and plant riparian woodland	900 feet					$12,000						$12,000
2-7	36	Urban	Plant riparian buffer along stream and on adjoining slopes in open space	9,100 feet					$216,000						$216,000
2-9	59	Urban	Off-line bioretention cells at 13 stormwater outfalls. Culvert retrofit at Crestwood Boulevard road crossing. Plant wildflower meadow throughout the wide swale.	1.7 acres			$215,000		$2,000		$4,000				$221,000
2-12	38	Urban	Construct off-line bioretention cell at stormwater outfall	500 sq. ft.			$17,000								$17,000
2-13	58	Urban	Off-line bioretention cells at four stormwater outfalls. Plant wildflower meadow throughout the wide swale.	4 acres			$66,000		$5,000						$71,000
2-15	44	Urban	Build off-line bioretention facilities at three stormwater outfalls in Ballenger Crossing Subdivision.	3,000 sq. ft.			$50,000								$50,000
2-16	29	Urban	Construct off-line bioretention cell at end of stormwater outfall	500 sq. ft.			$17,000								$17,000
2-17	48	Urban	Plant riparian buffer/wildflowers along King Branch	8,000 feet					$65,000						$65,000
2-18	31	Urban	Plant riparian buffer	2,300 feet					$63,000						$63,000
2-20	56	Urban	Stream restoration of King Branch	8,000 feet										$890,000 - $1,760,000	$890,000 - $1,760,000
3-4	31	Urban	Plant riparian buffer along Monocacy River at Driving range	1,000 feet					$42,000						$42,000
3-10	31	Agricultural	Plant riparian buffer along Monocacy River	200 feet					$16,000						$16,000
3-12	24	Agricultural	Plant riparian buffer along Monocacy River	2,500 feet					$68,000						$68,000
3-14	38	Agricultural	Plant riparian buffer along Monocacy River	6,600 feet					$160,000						$160,000
4-3	35	Urban	Construct off-line bioretention cell at stormwater outfall	500 sq. ft.			$17,000								$17,000
4-4	44	Agricultural	Stream stabilization and plant riparian buffer	4,000 feet										$490,000 - $1,020,000	$490,000 - $1,020,000
4-5	22	Agricultural	Enhance newly forming wetland	1 acre					$17,000						$17,000
4-6	41	Urban	Linear rain garden and bioretention along MD 180	7,000 sq. ft.	$68,000		$17,000								$85,000

Table 4-2. List of identified Community Restoration sites (continued)

Site No.	Total Score (max. 100)	Land Use	Proposed Action	Extent of Project (approximate)	Rain Gardens	Linear Rain Gardens	Off-line Bioretention	Berm	Plantings	SWM Pond Retrofit	Culvert Retrofit	Rain Barrels	Maintenance	Stream Restoration	Planning Level Cost Estimate (± 30 percent)
4-7	43	Agricultural	Eliminate mowing and plant riparian buffer within new stream exclosure	4,000 feet					$101,000						$101,000
4-8	26	Agricultural	Plant riparian buffer	1,000 feet					$34,000						$34,000
4-9	40	Agricultural	Plant riparian buffer	8,000 feet					$191,000						$191,000
4-11	49	Urban	Repair road culverts, bank stabilization, debris removal	1 acre									$18,000		$18,000
4-12	54	Urban	Rain barrel installation and LID education program for single family homes on large properties	50 Homes								$15,000			$15,000
4-13	54	Urban	Rain barrel installation and LID education program for single family homes on large properties	100 Homes								$30,000			$30,000
4-14	56	Urban	Rain barrel installation and LID education program for single family homes on large properties	50 Homes								$15,000			$15,000
4-16	54	Urban	Rain barrel installation and LID education program for single family homes on large properties	50 Homes								$15,000			$15,000
5-3	57	Urban	Repair bank erosion from stormwater pipe outfall and retrofit outfall with off-line bioretention cell	25 feet			$17,000							$12,000	$29,000
5-4	24	Urban	Construct rain garden for townhouse community near stormwater pipe outfall.	500 sq. ft.	$6,000										$6,000
5-13	48	Agricultural	Plant riparian buffer/bank stabilization along Ballenger Cr. above Pike Branch	6,000 feet										$1,670,000 *	$740,000 - $1,670,000
5-15	24	Agricultural	Plant riparian buffer	2,700 feet					$72,000						$72,000
5-16	44	Urban	Townhouse Community - rain barrel installation and LID education program	110 Town homes								$33,000			$33,000
5-17	41	Urban	Stream stabilization and plant riparian buffer	600 feet										$160,000 - $420,000*	$160,000 - $420,000
6-5	38	Agricultural	Plant riparian buffer	7,000 feet					$169,000						$169,000

* - Greater than 30% level of uncertainty due to complexity of site conditions; collection of additional data on site conditions and stressors will enable more refined cost estimates during future planning stages.

5.0 SUMMARY AND RECOMMENDATIONS

This study identified a number of site-specific watershed restoration opportunities available to the County to protect and improve Ballenger Creek's valuable water resources. While we have identified substantial opportunities for improvements at 15 Tier I sites, we consider this a preliminary prioritization (Table 5-1). We expect that the County will further refine these priorities and select from among these candidates based on additional factors and priorities that would influence successful implementation. As such, it is recommended that the County select a subset of high priority sites to pursue further through subsequent feasibility assessment(s) that would collect additional site-specific information, update ownership information and evaluate landowner cooperation, identify additional project constraints, further refine project approach and design, and determine if additional action is warranted for each high priority candidate site.

Opportunities for watershed improvement are not solely limited to these 15 Tier I sites because alternate avenues for implementation exist via the County's Community Restoration partners. Many of the CR and Tier II opportunities (Tables 4-1 and 4-2) are ideally suited for implementation by these groups and organizations, which can often leverage additional public support, outside sources of funding, and other resources to put projects "on the ground." Where possible, the County should lend support to these projects and programs.

Addressing stormwater management in karst area is an ongoing and important challenge in Ballenger Creek watershed, and elsewhere in the County. As discussed in more detail in Section 3-2, we recommend that Frederick County institute a karst overlay zone and develop specific, additional requirements that will guide development/redevelopment activities in these critical resource–sensitive areas.

Finally, we recommend that Frederick County use this list of candidate sites as a guide for selecting and implementing stormwater management and stream improvements. Because the County's priorities may change and other opportunities arise over time, the County should be free to respond accordingly in order to encourage, collaborate, or require improvements at any of the 74 candidate sites, and not just those currently identified in the Tier I list.

Table 5-1. Summary of candidate Tier I Sites for watershed restoration in Ballenger Creek, sorted in declining order by Total Score

Site No.	Total Score (max. 100)	Location	Summary of Proposed Action	Total Planning Level Cost Estimate (± 30%)
5-5	68	Mainstem near Ballenger Cr. Trail loop	Natural stream channel design restoration of channel geometry and riparian buffer enhancement.	$260,000 - $630,000*
2-11	64	Pike Branch behind Ballenger Cr. Middle School	Establish hydrologic connections between wetland and stream. Construct off-line bioretention cells at end of 13 stormwater pipe outfalls. Retrofit existing stormwater pond. Remove invasive species and enhance riparian buffer. Build walking/biking path to better connect school and development.	$833,000
5-2	60	Ballenger Cr. Elem. Sch. - Reach 1	Natural stream channel design restoration and riparian buffer enhancement. Restore outdoor classroom utility.	$160,000 - $420,000*
5-10	60	Ballenger Cr. Elem. Sch. - Reach 2	Natural stream channel design restoration and riparian buffer enhancement. Replace streambank concrete lining at sewer line crossing. Remove debris jam and accumulated trash.	$200,000 - $490,000*
2-2	57	Ballenger Cr. Middle School	Build linear rain gardens along the shoulder of Ballenger Creek Pike. Create grass filter strips with infiltration trench, and rain gardens in parking lot islands/borders. Divert roof drainage to rain gardens behind school. Reduction of overall non-used field areas by conversion to tree stands/greenways.	$92,000
4-1	54	Ballenger Cr. Park	Incorporate linear rain gardens along entrance road. Create rain gardens and filter strips in northern parking lot islands/borders and rain gardens and infiltration trench in southern parking lot. Create rain garden at outfall below baseball fields. Reduce overall non-used lawn areas by conversion to tree stands/greenways.	$144,000
5-1	53	Ballenger Cr. Elem. School	Incorporate linear rain gardens between sidewalks and Kingsbrook Drive. Create rain gardens and infiltration trenches in parking lot islands/borders. Create rain gardens in planting beds in front of school and near asphalt play areas. Increase buffer/greenway between residential community and school grounds.	$107,000
5-7	53	Ballenger Cr. Trail - loop and parking area	Incorporate LID techniques into current park planning effort. Build off-line bioretention cells at three existing discharges from the adjacent residential community. Preserve existing trees in place. Depress open space areas slightly (e.g., 1 inch) and enhance soils to facilitate depression storage and infiltration.	$113,000
6-3	49	Adult Detention Center	Depress open space areas slightly (e.g., 1 inch) and enhance soils to facilitate depression storage and infiltration. Create infiltration trenches in parking areas. Develop linear rain gardens along road front in depression near entrance and in existing drainage swales. Add rain garden in a traffic island adjacent to the parking areas.	$63,000
6-4	49	Dept. Utilities & Solid Waste Mgmt. office	Replace culverts beneath parking lots and retrofit stormwater outfall with an off-line bioretention facility. Repair scour hole and restore intermittent channel. Incorporate linear rain gardens along Marcie's Choice Lane. Create rain gardens in parking lot islands/borders. Install green roofed carports in parking areas.	$213,000
5-12	47	Robin Meadows Subdivision	Build off-line bioretention gardens at 12 stormwater pipe outfalls within the subdivision and rain gardens at three other locations. Plant a wildflower meadow throughout the bottom of the wide swales. Stabilize the streambank where the flow from the central swale enters the stream, located near the end of Mallard Lane.	$240,000
2-5	46	Frederick Village Subdivision	Plant 50-foot wide riparian woodland buffer around pond and along streams. Plant wildflower meadows in open space. Build off-line bioretention cells at end of five stormwater pipe outfalls.	$171,000
2-6	46	Foxcroft II Subdivision	Plant wildflower meadows in open space. Build off-line bioretention cells at four stormwater outfalls.	$69,000
2-1	44	Orchard Grove Elem. School	Incorporate linear rain gardens along Hanover Drive. Create grass filter strips with infiltration trenches and rain gardens in parking lot islands/borders. Convert planting beds into rain gardens to receive redirected roof drainage. Install two rain gardens in lawn areas at stormdrain inlets. Increase buffer/greenway between residential community and school grounds. Include shade trees in parking areas.	$190,000
5-9	44	Ballenger Cr. Trail above New Design Rd.	Construct linear rain gardens along New Design Road and an off-line bioretention cell at a stormwater pipe outfall. Preserve existing trees and enhance the riparian buffer. Depress open space areas slightly (e.g., 1 inch) and enhance soils to facilitate depression storage and infiltration.	$109,000

* Greater than 30% level of uncertainty due to complexity of site conditions; collection of additional data on site conditions and stressors will enable more refined cost estimates during future planning stages.

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APPENDIX

Public Workshop Presentation Materials

Public Workshop to Identify Watershed Restoration Opportunities in Ballenger Creek

April 21, 2005 – Ballenger Creek Elementary School

1. Introduction
   - Project Team introductions
   - Background: protection of watersheds in Frederick County
   - Objectives for the meeting
   - Objectives of the Ballenger Creek Watershed Study

2. Main Presentation
   - Overview of current conditions within Ballenger Creek watershed
   - Problems affecting streams in the watershed
   - Solutions: types of opportunities for improvements
   - How the public can help
   - Introduction to the Problem and Opportunity Identification Exercise

3. Problem and Opportunity Identification Exercise
   - Break out into several groups and gather around stations to discuss and suggest public ideas – watershed broken in 3 pieces – Eastern, Central, and Western
   - Each station will have:
     - A large format map of a portion of Ballenger Creek watershed
     - Problem and Opportunity Identification cards to fill out; Project Team staff will plot location on map with the help of those making suggestions
     - Project Team staff with which to discuss problem areas, potential solutions, concerns, etc.

We Appreciate Your Participation!

Project Team:

Frederick County, Division of Public Works	***Versar, Inc.***	
Shannon Moore	Morris Perot	Nancy Roth
Kay Schultz	Mike Klevenz	Jennifer Shore

For periodic project updates and additional information on the County's efforts to preserve and protect clean water, visit the County's new web site:

www.co.frederick.md.us/NPDES/

Or, contact: Shannon Moore, Frederick County NPDES Program Coordinator, at (301)694-1413, or smoore@fredco-md.net.

Problem and Opportunity Identification Card

Suggestion No.: _______   *(For County use only)*

Ballenger Creek Watershed Restoration Study - 4/21/2005
Frederick County, MD

Location of Problem (address, street, nearest cross-street, property owner, etc.): ____________________

____

Description of Problem (sketch on back): ____

____

____

(Optional) Suggested Remedy:____

____

____

(Optional) Please provide the following contact information should we have additional questions regarding your suggestion:

Name:____

Phone: ____________________ Email: ____

Problem and Opportunity Identification Card

Ballenger Creek Watershed Restoration Study - 4/21/2005
Frederick County, MD

Suggestion No.: _______   *(For County use only)*

Location of Problem (address, street, nearest cross-street, property owner, etc.): ____________________

____

Description of Problem (sketch on back): ____

____

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(Optional) Suggested Remedy:____

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(Optional) Please provide the following contact information should we have additional questions regarding your suggestion:

Name:____

Phone: ____________________ Email: ____